AEROBIC CAPACITY AND HABITUAL PHYSICAL ACTIVITY IN THREE GROUPS OF APPARENTLY HEALTHY MALAY MALES

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INTRODUCTION

The ability of the cardiovascular system to provide sufficient oxygen to the cells and remove waste products of metabolism during activity is an important determinant of physical work capacity. The circulatory system is generally the weakest link in the oxygen transport system and the limiting factor is the maximum amount of blood the heart ejects per minute. Ventilatory and diffusion capacities of the lungs, unless significant lung disease is present, are not limiting factors except at high altitudes. Hence measuring maximal oxygen uptake gives a valuable index to the functional state of the cardiovascular system. The American Heart Association Committee on Exercise makes use of this in classifying cardiorespiratory fitness in the handbook for the physician (1972). Maximal oxygen uptake or aerobic capacity is defined as the level of oxygen uptake at which an increase in workload no longer produces an increase in oxygen uptake. Astrand and Rodahl (1970) reported that habitual physical activity is one of the factors that affect aerobic capacity and that strenuous physical training may produce a 20 - 30 percent increase in maximal oxygen uptake and a period of bed rest of less than a month may cause an equally large decrease. In view of the numerous reports that associate low habitual physical activity with coronary heart disease, (Rechnitzer *et al.* 1972, Fox *et al.* 1971, and Froelicher and Oberman, 1972) it is imperative to assess the cardiovascular fitness of groups of individuals engaged in varying levels of activity and who are asymptomatic for ischaemic heart disease. It is hoped that such data can be used as a baseline for assessing cardiovascular fitness and physical work capacity of individuals with coronary disease. This paper aims to correlate the maximal oxygen uptake with the habitual physical activity of forty two Malaysian males above the age of 35 years.

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MATERIAL AND METHOD

The volunteers were members of the Malaysian Police Force. Their habitual physical activity was estimated by interview using a standard questionnaire which included the following: the number of working days; type of activity and number of hours at each activity (e.g. walking, standing, sitting); any regular exercise programme involving jogging, running, walking, cycling; previous sports activity in school; recreational activity (e.g. soccer, sepaktakraw, yard work/gardening). A detailed clinical history was taken which included family history and past and present history with emphasis on possible symptoms of ischaemic heart disease. A complete physical examination was done on all volunteers to exclude any cardiorespiratory illness or any disease which could affect physical work capacity. This was supplemented by a chest X-ray, biochemical investigations (haemoglobin, cholesterol, blood glucose, serum triglyceride), a resting EKG and lung function tests. Blood was taken approximately 2½ hours after breakfast.

The ages of the volunteers ranged from 35 years to 53 years with a mean of 44.5 years. They were all asymptomatic for ishaemic heart disease. On physical examination increased systolic blood pressure ($>$140mmHg)was found in 28 (66 percent) of the volunteers and 22 (52 percent) also had elevated diastolic pressure ($>$100mmHg). There were no other significant physical findings. All the volunteers had normal chest X-rays, haemoglobin above 12gm/100ml, normal resting EKG and lung function tests which included diffusion studies.

Their heights ranged from 157.5 to 173.4 cm with a mean of 164.6 cm and their weights from 44.5 kg to 95.5 kg with a mean of 66.2 kg respectively. Results of the biochemical investigations are summarized in Table I.

Maximal oxygen uptake ($V_{O_{2max}}$) was measured by a submaximal method. The subjects worked on a bicycle ergometer at discontinuous increasing workloads until the target heart rate of 85 percent of maximum was achieved. The maximum heart rate was determind by the formula: 220-current age in years.

The protocol for the exercise was to cycle for 4 minutes to 60 revolutions/minute and rest for 3 minutes before starting the next workload. Expired air was collected, the total volume for one minute measured and analysed for oxygen and carbon dioxide concentration, when the heart rate for each workload reached a steady state. Oxygen uptake (consumption) was measured using the following formulae:

(1) O_2uptake (ml/min) = $V_{I_{O_2}}$ $V_{E_{O_2}}$

V = Volume of inspired and expired air in ml at STPD.

I_{O_2} and E_{O_2} = Concentration (%) of O_2 in inspired and expired air respectively.

(2) Volume of inspired air =

$$\text{vol expired air X } \frac{\%\ N_2 \text{ in expired air}}{\%\ N_2 \text{ in inspired air}}$$

A graph of oxygen consumption versus heart rate was then drawn and the curve extrapolated until it intersected a horizontal line drawn through the age adjusted maximal heart rate. This represented the maximum point at which the cardiovascular system was stressed.

RESULTS

(a) Habitual Physical Activity

Analysis of the information obtained from the habitual physical activity questionnaire revealed the following major types of physical activity.

Group One: Consists of ten men who do guard duty in two four-hour shifts per day for six days a week. The duty involves a lot of standing and a little walking and sitting. They are not involved in recreational activities. Some do yard work/ gardening but otherwise they have no regular exercise programme.

Group Two: consists of twelve men who do a regular eight hour/day job which includes duties like rostering, supervising the labourers and security of office and other buildings. Most of the time they are at the desk. They are not active in sports and do not have a regular exercise programme.

Group Three: Consists of twenty men who do operational duty in the jungle at least 3-4 times a year, each time lasting from 3-4 months. While in camp (not on operations) the men undergo drill at least 4 times a week. This involves exercises and jogging for at least 2 miles lasting for about 1 hour. Some of the men are active in soccer, badminton, athletics, table tennis and walking.

The men have been involved with their present jobs for at least two years and some have been doing the same job for more than ten years. According to the classification of occupational activity obtained from the Dictionary of Occupational Titles, U.S. Department of Labour, group one and two would be placed in the light category with peak $V_{O_{2max}}$ during activity being 7 ml/kg/min while those in group three would be in the medium to heavy class with peak $V_{O_{2max}}$ being 20-27 ml/kg/min or even exceeding 27ml/kg/min. Other activities classified as light are domestic work, laboratory and hospital work, professional activities and light industry. Those classified as medium to heavy include building and construction, agriculture and steel industry and armed services.

(b) Biochemical Findings:

The mean serum cholesterol, blood sugar and triglyceride levels were all within normal limits. The cholesterol levels were found to be higher in group II and III but the differences were found not

TABLE I
BIOCHEMICAL FINDINGS IN THREE GROUPS OF MALAYSIAN MEN ABOVE 35 YEARS WITH DIFFERING AMOUNT OF PHYSICAL ACTIVITY.

Group	Serum cholesterol (mg/100ml)	Serum triglyceride (mg/100ml)	Blood sugar (mg/100ml)
I	202 ± 14	99 ± 19	83 ± 6
II	217 ± 7	78 ± 13	87 ± 7
III	225 ± 9	179 ± 23*	93 ± 3

Figures are given as Mean ± S.E.M.
* Significant difference

significant ($p > 0.1$). No significant differences in blood sugar levels were noted between groups. The serum triglyceride level was significantly higher in group III men ($p < 0.01$). The reason for the difference could be due to dietary habits. The dietary history indicates that breakfast is more regular as a meal for men in group three than for men in the other two groups.

(c) Physical Characteristics and Aerobic Capacity

Physical characteristics of height, age and weight were not significantly different between groups. The resting systolic blood pressures were strikingly raised above normal especially in men of group three. The diastolic pressure was within normal limits for men in group one and two but slightly raised for men in group three. Aerobic capacity was significantly higher ($p < 0.01$) in the active individuals in group III. The cardiorespiratory fitness based on the reference standard of the American Heart Association (1972) for men aged 40-49 years is fair for group 1 (20-27 ml/kg/min) and average for group II (28-34 ml/kg/min) while that of group III is good (35-44 ml/kg/min). The average 0_2 uptake of reference men aged 40-49 years is 31 ml/kg/min while that for this study is 30.8 ml/kg/min.

DISCUSSION

This study has shown that physically more active individuals not only have significantly higher $V0_{2max}$ than those more sedentary but also higher systolic and diastolic pressure although the values do not differ statistically from the sedentary group. These data differ from the results of Choquette and Ferguson (1973) who showed decrease in arterial blood pressure with regular exercise. The generally raised systolic pressure is striking. Whether or not it is the consequence of stress induced by the experimental procedures cannot be assessed at present. Results of blood pressure recordings on follow-up have not conclusively shown that this is the main cause. If indeed stress is the answer, is there any reason for the greater reaction seen in men in group three? If stress is not the answer to these elevated mean blood pressure then should some of these volunteers be considered as hypertensive? At present available data are inadequate to answer the questions.

This investigation has also revealed the low cardiorespiratory fitness of men in the 40-49 years age group who are involved in light occupation compared to the physically active men whose measurement of fitness ranges from average to high. This difference is especially significant when possible variability in $V\ 0_{2max}$ due to age, have been minimised in this study. Other variables like effects of smoking, diet and stress, however, have not been excluded. On the average, the aerobic capacity of this group of Malay men (30.8 ml/kg/min) compares favourably with that obtained from western men (31 ml/kg/min).

A higher $V0_{2max}$ indicates that the ability to do high levels of cardiovascular work are increased. This means that the cardiovascular system is able to provide large quantities of oxygen to the cells during work and carry away large quantities of lactic acid. Therefore, energy is produced using the more efficient energy producing pathways for longer periods of time. It also means that compared to a person with a lower $V0_{2max}$ the heart works less hard to accomplish the same amount of work.

Astrand and Rodahl (1970) have shown that the $V0_{2max}$ can be increased by about 30% by a regular exercise programme and has often been used as an indicator of progress in cardiac rehabilitation programmes. Other effects of regular exercise on the functional status of the cardiovascu-

TABLE II
PHYSICAL CHARACTERISTICS AND AEROBIC CAPACITY OF THREE GROUPS OF MALAYSIAN MEN WITH DIFFERING AMOUNTS OF PHYSICAL ACTIVITY

	Age (yrs)	Blood Pressure Syst. (mm Hg)	Diastolic (mm Hg)	Height (cm)	Weight (kg)	V_{O_2max} (ml/min/kg)
Group One (light activity)	45.2 ± 2.0	137.0+ ± 5.0	96.0 ± 3.7	163.9 ± 1.4	63.3 ± 3.4	27.5 ± 2.1
Group Two (Light activity)	45.6 ± 1.5	135.8+ ± 5.2	93.3 ± 2.3	165.4 ± 1.7	68.3 ± 3.9	29.8 ± 2.4
Group Three (medium to heavy)	42.8 ± 1.0	148.5+ ± 3.8	101.0+ ± 2.8	164.6 ± 0.8	66.9 ± 2.3	35.0* ± 1.3

Figures are given as Mean ± S.E.M.
* Significant difference ($p \leq 0.01$)
+ above normal

lar system that have been reported are an increased myocardial efficiency, (Detry *et al,* 1971, Ericsson *et al,* 1970) increased effectiveness of peripheral blood distribution (Ericsson *et al,* 1970), greater electron transport capacity (Holloszy, 1967), increased fibrinolytic capability, (Guert and Celander, 1960), decreased serum lipid level (Holloszy *et al,* 1964, Goode *et al,* 1966), lower arterial blood pressure, (Choquette and Ferguson, 1973), and decreased vulnerability to dysrythemias (Blackburn *et al,* 1973).

Although $V_{O_{2max}}$ accurately measures the functional capacity of the circulatory system, it cannot be used to diagnose the absence or presence of heart disease. The measurement reflects the interaction between normal variability and severity of the disease. In other words it measures the functional impact of a given lesion on the total oxygen transport system rather than the severity of the lesion in terms of anatomy or measurements related to particular aspects of the cardiovascular system. For example, severe stenosis of a single coronary artery may cause angina pectoris at very low workload compared to triple vessel disease with adequate collaterals and a nearly normal workload.

The use of $V_{O_2\ max}$ also provides a common denominator for results obtained by different test methods, e.g. treadmill, bicycle, or two step. It is also an objective measurement of the functional status of a cardiac patient compared to a classification based on the patients' symptom.

Our data show that occupational activity has a significant impact on the functional state of the cardiovascular system. Whether in the long run this impact will be reflected by a lower incidence of a coronary heart disease in men of group three, only the future will tell. In the last two decades numerous studies have been done to show the relationship between occupational or total life physical activity and the frequency of heart attacks. However, in the literature there are data both in support of (Fox and Skinner, 1964, Fox *et. al,* 1971 and Froelicher and Oberman, 1972) and which question (Keys, 1970) the value of exercise in reducing the incidence of coronary heart disease.

However in spite of the conflict in data and its interpretation the amount of physical activity recommended which improves the functional capacity of the cardiovascular system is not great and the amount of exercise necessary can be achieved easily even for those in a city environment. It is also probable that the activity itself is more important (McPherson *et al,* 1967) than the fitness result achieved by the exercise programme, giving more life to years as well as years to life.

In conclusion, the data in this report confirmed the viewpoint that regular physical activity is important in maintaining an efficient cardiorespiratory function and that the life style of an individual can determine to a great extent, this functional capability.

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