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A STUDY OF CARDIO-PULMONARY EFFICIENCY IN DIFFERENT CATEGORIES OF RUNNERS

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Abstract : Selected short distance runners, middle distance runners and long distance runners were subjected to graded exercise on a treadmill. The maximum aerobic power ($\dot{V}O_2$max) and other indices related to oxygen transport system viz. heart rate, ventilation volume, breathing reserve, dyspnoeic index, O_2pulse and RQ were recorded at respective $\dot{V}O_2$max work loads, and the values were compared. Long distance runners and middle distance runners showed a significantly higher $\dot{V}O_2$max than the short distance runners when $\dot{V}O_2$max was expressed per unit of body weight. Among the endurance runners, long distance runners had a significantly lower resting pulse rate as well as the maximum heart rate during work than the middle distance runners. On comparison, Ventilation Volume, Breathing reserve, Dyspnoeic index, O_2 pulse and RQ at $\dot{V}O_2$max work loads do not differ significantly among different categories of runners.

Key words : short distance runners (SDR) middle distance runners (MDR) long distance runners (LDR) cardio-pulmonary efficiency $\dot{V}O_2$max heart rate (HR) O_2 pulse RQ breathing reserve (BR) dyspnoeic index (DI) M.V.V.

INTRODUCTION

Several factors like heredity, environment, diet, training, hormone status, socio-economic status, psychological trait etc. contribute to the performance of a sportsman (1, 2, 3, 4, 5). Various events of sports and games demand combination of various ratios of strength, flexibility, agility, endurance, aerobic and anaerobic capacity etc. (6, 7, 8). Further even, in the same type of event, for example run, the elite performers of various distance runners have been shown to differ regarding their

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metabolic as well as physical responses (7, 9, 10, 11). The efficiency related to various systems with special reference to cardio-pulmonary aspect play a major role in various distance runners (1, 2, 13). However, the difference of such functional capabilities has not been well documented in the different types of runners of this country. The present study was undertaken to assess the cardio-pulmonary aspects of different types of runners of our country and to compare them to note the difference, if any. Such study may be of use to understand the effect of training, to evaluate the training schedule, to assess the efficiency and/or potentiality of a runner.

METHODS

A team of male runners undergoing training was selected for the present study. The present runners were divided into three groups according to their proficiency in different events. The first group of runners participate in 100 metres and/or 200 metres race and designated as short distance runners (SDR). The second group participate in 800 metres and/or 1500 metres race and designated as middle distance runners (MDR). The third group was 5000 metres, 10,000 metres or marathon (42 km.) runners and designated as long distance runners (LDR). The physical characteristics like age, height, weight, surface area and resting pulse rate (RPR) were noted in the subjects prior to test. The timing of runners in their respective events of run were also noted.

Maximum oxygen consumption rate ($\dot{V}O_2$ max) for all the subjects were determined during graded exercise on treadmill running at 11 km per hour (Quinton Co., Washington) at different inclinations (14). The values of O_2 consumption and CO_2 output at various work loads were determined from the obtained values of inspired air (room air) composition, expired air composition and expired air volume (STPD). The values of RQ were subsequently calculated. The values of $\dot{V}O_2$max was obtained when $\dot{V}O_2$ did not increase despite an increase in workload or when the difference of $\dot{V}O_2$ between two final successfully completed work deferred by less than 150 ml/min (15).

Heart rate (HR) was noted immediately after stoppage of exercise. Maximum voluntary ventilation (MVV) values were determined prior to exercise tests by the help of expirograph (Toshniwal). From the obtained values of MVV and ventilation volumes ($\dot{V}E$) the values of breathing reserve (BR) and dyspnoeic index (DI) were calculated (15).

O_2 pulse is obtained by dividing O_2 consumption in ml/min. by the heart rate. The above values at $\dot{V}O_2$ max work load are designated as max HR, max $\dot{V}E$, max O_2 pulse, max RQ, BR at $\dot{V}O_2$ max and DI at $\dot{V}O_2$max.

Standard statistical methodologies were applied in terms of mean, standard deviation and 't' test for comparison between the groups.

RESULTS

The results are summarised in Table I, II, III and IV.

TABLE I : Physical characteristics and resting pulse rate of the runners (mean ± SD).

	Age (yr)	*Height (cm)*	*Weight (kg)*	*Surface area (m^2)*	*RPR*
SDR (n=8)	27.87±3.09	173.56±4.45	63.71±2.58	1.765±0.5	69.25±8.34
MDR (n=3)	26.33±3.78	174.5±1.5	59.633±5.16	1.72±.052	81.33±11.55
LDR (n=5)	27.4±3.78	173.4±3.84	57.9±5.16	1.696±0.98	64.8±9.01

TABLE II (a) : Timings of short distance runners in second.

Name	*100 meters*	*200 meters*
JV	11.2	23.0
RD	11.6	–
LS	11.5	23.0
BS	11.0	22.0
HS	11.8	23.2
SS	11.1	–
JK	11.4	23.2
OS		

TABLE II (b) : Timings of middle distance runners in minute : second.

Name	*800 meters*	*1500 meters*
VS	–	4 : 7
PS	2.20	–
RS	–	4 : 8

TABLE II (c) : Timings of long distance runners in minute : second.

Name	*5000 meters*	*10000 meters*	*Marathon (42 km)*
SL	–	–	157 : 22
KS	–	–	165 : 28
BP	–	–	155 : 40
MR	15 : 22	–	–
SC	15 : 35	32 : 58	–

TABLE III : Cardio-respiratory functions of different categories of runners during exercise tolerance (Mean ± SD).

	SDR	*MDR*	*LDR*
$\dot{V}O_2$ max (Lit/min)	2.95±0.35	3.12±0.42	2.96±0.33
$\dot{V}O_2$ max (ml/kg/min)	46.24±5.18	52.26±2.8	51.03±1.96
Max HR	197.5±20.61	213.3±12.22	182.8±19.78
Max $\dot{V}E$ (lit/min)	85.70±9.74	98.47±16.88	90.95±20.41
Max O_2 pulse	15.09±1.52	14.82±1.66	16.32±2.44
BR at $\dot{V}O_2$ max	45.83±27.34	47.49±7.6	44.09±12.82
DI at $\dot{V}O_2$ max	32.1±13.92	32.51±0.91	33.07±10.65
Max RQ	0.95±0.04	0.97±0.03	1.05±0.10

DISCUSSION

The data enlisted in Table I show that all the runners belong to similar age group. The LDR had significantly lower body weight ($P<0.05$) than SDR. MDR though had lesser body weight than SDR were not statistically significant. The SDR are as a rule different than the endurance runners in that short distance running utilise greater amount of energy from anaerobic than aerobic sources. Further long distance running requires greater utilisation of fatty acids than carbohydrates unlike the short distance running where utilisation of carbohydrate predominates (16). This may

TABLE IV : Statistical comparison of cardio pulmonary functions among various groups of runners.

	SDR Vs MDR	*SDR Vs LDR*	*MDR Vs LDR*
$\dot{V}O_2$ max (lit/min)	NS	NS	NS
$\dot{V}O_2$ max (ml/kg/min)	S	S	NS
Max HR	NS	NS	S
Max $\dot{V}E$	NS	NS	NS
MaxO_2 Pulse	NS	NS	NS
BR at $\dot{V}O_2$ max	NS	NS	NS
DI at $\dot{V}O_2$ max	NS	NS	NS
Max RQ	NS	NS	NS

S = Significant (P<0.05) and NS = Not significant.

be the reason of having a lower body weight in LDR and MDR as a long term response. In the present study LDR show significantly lower RPR (P<0.05) than MDR (Table I). Further the LDR had significantly lower max HR than the MDR (Table III and IV). These differences in cardiac functioning between LDR and MDR may be one of the contributing factors for opting sustained or less sustained distant run.

The $\dot{V}O_2$ max as well as ammonia and lactate estimations have been utilised to assess overall physical work capacity as well as cardio-pulmonary efficiency (10, 11). It has been noted that physical training increases $\dot{V}O_2$ max (17, 18, 19). Further, cross country, skiers, LDR, MDR and speed skaters etc. were reported to possess higher aerobic capacity (20). In the present study all the groups of runners show similar absolute value of $\dot{V}O_2$ max. However, when $\dot{V}O_2$ max was calculated per unit of body weight both LDR and MDR had significantly higher values than the SDR (Table III and IV). In fact, $\dot{V}O_2$ max when related to body weight is a better expression for evaluating the ability for moving the body (21). A direct relation between body weight and $\dot{V}O_2$ max has also been established (21). It is, therefore, that SDR were differentiated from the MDR & LDR by functional state of aerobic capacity when $\dot{V}O_2$ max was expressed as a function of body weight. The present runners show lower values of $\dot{V}O_2$ max and timings in their specific event of run (Table II) than the similar type of top Indian runners (23) and world class runners (20, 24). In fact, the best index of physical fitness is the performance in competitive sports. It seems to establish that $\dot{V}O_2$ max is certainly an index of athletic performance per excellence.

The values of max $\dot{V}E$ which reflect many factors including compliance of lungs, chestwall and respiratory muscles were shown to be similar in all groups. These values of max $\dot{V}E$ were again lower than top Indian and world class runners (20, 23, 24). Normally it is believed that work of breathing is a limiting factor in heavy physical work as it consumes about 10 percent of total oxygen uptake (25). However, probably the optimum limit of max $\dot{V}E$ need to be more in athletes to maintain the O_2 tension in arterial blood. The present runners have similar ventilatory reserve as their BR at $\dot{V}O_2$ max were found to be similar. The present LDR and MDR who require a higher value of $\dot{V}O_2$ max seem to lack the extra ventilatory reserve which may contribute in achieving a significant higher absolute value of aerobic power. The LDR & MDR however, are superior in aerobic power to the SDR by virtue of their less body weight.

O_2 pulse normally portray the stroke volume and average arteriovenous

O_2 difference. Training normally increases both stroke volume and O_2 extraction by the tissues (16, 17). All the runners of this study have regular practice of run and other physical activities and could not be differentiated by the index of max O_2 pulse.

DI at $\dot{V}O_2$ max are similar in all the groups showing that all the runners were equal in degree of breathlessness at their $\dot{V}O_2$ max workload. The DI at $\dot{V}O_2$ max values are probably the indicator of limit for exercise tolerance.

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