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Maximal Aerobic Capacity of Bengali Girl Athletes of Different Sports Activities

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Abstract The maximal aerobic capacity ($\dot{V}_{O_2\,max}$) and related cardio-respiratory parameters were determined on 67 Bengalee (Indian) girl athletes having nine different sports activities. $\dot{V}_{O_2\,max}$ was determined with a bicycle ergometer. The highest value for $\dot{V}_{O_2\,max}\,l\cdot min^{-1}$ was obtained by javelin throwers (1.95), being followed by pentathletes (1.92) and long-distance runners (1.90), whereas the lowest value was achieved by handballers (1.45). When $\dot{V}_{O_2\,max}$ was expressed in $ml\cdot kg^{-1}\cdot min^{-1}$, the long-distance runners registered the highest mean value (43.0), which was significantly higher than that of basketballers (34.9), handball players (36.2), badminton players (34.4), and swimmers (36.0). For this measurement, the sprinters (40.0), pentathletes (40.3), javelin throwers (40.0), and jumpers (39.4) did not differ significantly with each other, but each of the groups was significantly superior to basketballers, handballers, badminton players, and swimmers. No significant difference was also found amongst the latter groups. $\dot{V}_{O_2\,max}\,l\cdot min^{-1}$ was found to be significantly correlated with all the physical characteristics. It was predicted on the basis of age, height, weight, and body surface area using stepwise regression method.

Key words: Bengalee girl athletes, friction-type bicycle ergometer, maximum oxygen uptake.

Maximal aerobic capacity ($\dot{V}_{O_2\,max}$) has generally gained acceptance as being the most accurate measure of the organism's circulatory and respiratory capacity (ÅSTRAND, 1956). Exercise physiologists have agreed that the ability to perform hard physical work is related to the maximal capacity of the cardiovascular-respiratory system to take up, transport and give off oxygen for its utilization

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(TAYLOR *et al.*, 1955; ÅSTRAND, 1956; HETTINGER *et al.*, 1961).

Involvement of large numbers of women in programs that stress some forms of vigorous exercise is relatively a recent phenomenon. Thus there is relatively little specific information available concerning the physiological changes in women caused due to participation in different sports activities (HERMANSEN and ANDERSEN, 1965; SALTIN and ÅSTRAND, 1967; FOX *et al.*, 1969; SPRYNAROVA and PARIZKOVA, 1969; MATSUI *et al.*, 1972; JOUSSELIN *et al.*, 1984). In India, no information is available concerning maximal aerobic capacity of different categories of girl athletes till this date. Therefore, the objectives of the present investigation are: i) to evaluate the maximal aerobic capacity ($\dot{V}_{O_2\,max}$) amongst different categories of girl athletes of Bengal (eastern region of India) and ii) to compare the obtained values amongst them, involved in different sports activities.

MATERIALS AND METHODS

Sixty-seven Bengalee (Indian) girl athletes having nine different sports activities were included for the study. The different events were long-distance running ($n=5$), sprint ($n=13$), pentathlon ($n=3$), jumping ($n=5$), javelin ($n=4$), basketball ($n=13$), handball ($n=7$), badminton ($n=6$), and swimming ($n=11$). The majority of the subjects were of either national or of state level. Some of them were also of intercollegiate or interschool standard. Each of the subjects had a minimum of 4 years of training history. All the subjects taken for different tests were in their full form of regular practice.

Preparation of subjects. The subjects were requested to refrain from eating, drinking, or doing any strenuous physical work at least for 2 h before the onset of experiment. Each subject was allowed to take a rest for a minimum period of half an hour so that the pulse rate might come down to a steady state. At the end of this period of initial rest, pre-exercise heart rate was noted by counting the beats for 1 min, feeling the palpation of the carotid artery. The physical parameters of the subjects were measured before the onset of experiment.

Determination of $\dot{V}_{O_2\,max}$. $\dot{V}_{O_2\,max}$ of all categories of sports participants was determined on a magnetic friction-type bicycle ergometer (Model of Prof. E. A. Müller, Max Planck Institute for Work Physiology) as no other alternative was possible in our laboratory. A low-resistance, high-velocity, Collins "Triple J" type plastic valve was used for the collection of expired air by the open circuit method.

A preliminary warming up for 5 min at a rate of 600 $kg\cdot m\cdot min^{-1}$ was given to each subject before the application of a set workload which was fixed at 720 $kg\cdot m\cdot min^{-1}$. The pedaling rate was kept constant at 60 rpm with the help of a metronome. The workload thereafter was increased by 120 $kg\cdot m\cdot min^{-1}$ at an interval of every 2 min till the subject gave indication of complete exhaustion. Maximum heart rate (HR_{max}) being a good indicator of the effort put in, care was taken to judge the validity of the exhaustive withdrawal by checking the maximum heart rates during maximum workload. In most of the cases, HR_{max} were recorded above 180 beats·min^{-1}. In the present study, the workload was considered to be maximum when no further increase in oxygen uptake took place despite further increase in workload, or the increase in uptake was less than 100 ml·min^{-1} in response to the next higher load for repeated tests in the following days (ÅSTRAND, 1952, 1690). Subjects in no case endured more than 10 min in this procedure of a continuously increasing workload.

Measurements of HR_{max}, maximal pulmonary ventilation ($\dot{V}E_{max}$) during the test for maximal oxygen intake and analysis of expired gas were made according to the procedure described in our earlier report (CHATTERJEE and CHAKRAVARTI, 1986).

Gas analysis. The expired gases were collected in 150 *l* Douglas bags in the last minute of the final workload. However, sometimes the gas collection was also made earlier, i.e. in the 2nd minute of the final workload if signs of complete exhaustion supervened. No gas collection was made in the 1st minute of any workload. Gas volume was measured in a wet gasometer and an aliquot of the inspired air was analyzed by Scholander microgas analysis apparatus following the standard procedure described by CONSOLAZIO *et al.* (1963). The $\dot{V}_{O_2\,max}$ values thus obtained were finally corrected to STPD. Several trials were made in each case and the highest value of $\dot{V}_{O_2\,max}$ thus obtained was recorded.

Pulmonary ventilation during maximal workload ($\dot{V}E_{max}$). The $\dot{V}E_{max}$ during each type of exercise was determined by measuring the expired gas volume during the last minute of exhaustive exercise using a wet gasometer and was corrected to BTPS.

Heart rate. The maximal heart rate was recorded manually from the time taken for ten carotid pulsations immediately following the cessation of exhaustive exercise (ÅSTRAND and RODAHL, 1970).

The experiments were performed at a room temperature varying from 27–29°C with the relative humidity varying between 60–70%.

RESULTS

Mean±S.D. for physical characteristics, $\dot{V}_{O_2\,max}$ and its related parameters in 67 girl athletes of nine sports activities are represented in Table 1. The mean ages ranged from 14.7 years in badminton to 24.5 years in pentathlon. The analysis of variance (ANOVA) reveals a highly significant variation ($p<0.001$). The procedure of pairwise multiple comparison showed that 17 of the 36 pairs were significantly different. Each mean of handball and badminton players was significantly lower than each group of long-distance runners, sprinters, jumpers, and javelin throwers (8 comparisons). Mean age of pentathletes was significantly higher than all other categories of athletes except for long-distance runners (7 comparisons). Swimmers were significantly younger than basketballers while handballers than long distance runners (2 comparisons). All groups of athletes were comparable to each other for their height, weight and BSA. No significant difference was noted

Table 1. Mean values and standard deviations for physical characteristics, heart rates, $\dot{V}_{O_2\,max}$, and related cardio-respiratory functions with the analysis of variance in girl athletes of different sports activities and all sports.

	Long-distance running ($n=5$)	Sprint ($n=13$)	Penta-thlon ($n=3$)	Jump-ing ($n=5$)	Jave-lin ($n=4$)	Basket-ball ($n=13$)	Hand-ball ($n=7$)	Badmin-ton ($n=6$)	Swim-ming ($n=11$)	F com-puted	All sports activities combined ($n=67$)
Age (years)	18.7	17.9	24.5	17.6	17.9	16.6	16.1	14.7	14.8	5.48	17.0
	±2.9	±3.3	±1.3	±2.8	±1.9	±1.8	±1.0	±2.7	±3.0	****	±3.2
Height (cm)	152.2	153.6	158.5	157.8	155.6	156.7	150.4	153.4	151.7	1.79	154.1
	±4.5	±5.2	±2.8	±5.8	±3.2	±7.3	±2.2	±4.1	±5.3		±5.5
Weight (kg)	44.3	43.6	47.3	45.2	48.9	44.3	33.9	44.6	43.2	1.48	44.0
	±5.0	±3.8	±4.6	±5.4	±5.9	±4.6	±3.4	±5.6	±5.3		±4.9
BSA (m^2)	1.4	1.4	1.5	1.4	1.5	1.4	1.3	1.4	1.3	0.03	1.4
	±0.1	±0.1	±0.1	±0.1	±0.1	±0.1	±0.1	±0.1	±0.1		±0.1
Pre-exercise heart rate	65	75	71	77	67	76	70	77	79	1.49	74
(beats·min^{-1})	±10.8	±10.8	±3.1	±6.6	±4.4	±7.4	±7.8	±10.7	±13.8		±10.1
HR_{max} (beats·min^{-1})	180	191	191	192	182	192	190	195	197	1.28	191
	±11.3	±11.6	±6.1	±22.0	±6.0	±10.7	±7.5	±12.1	±11.9		±11.9
$\dot{V}_{O_2\,max}$ ($l\cdot min^{-1}$ STPD)	1.89	1.77	1.91	1.79	1.95	1.54	1.45	1.54	1.54	5.28	1.7
	±0.1	±0.2	±0.3	±0.3	±0.3	±0.2	±0.2	±0.2	±0.2	****	±0.2
$\dot{V}_{O_2\,max}$	43.2	40.7	40.3	39.4	40.1	34.9	36.2	34.4	36.0	7.11	37.8
($ml\cdot kg^{-1}\cdot min^{-1}$ STPD)	±4.9	±2.5	±3.4	±3.9	±2.8	±1.9	±2.9	±2.3	±3.9	****	±4.1
$\dot{V}E_{max}$ ($l\cdot min^{-1}$ BTPS)	57.2	61.1	59.2	65.0	60.5	62.5	56.9	54.6	51.2	2.41	58.6
	±5.5	±6.5	±5.1	±8.8	±3.0	±8.8	±9.7	±4.8	±10.2	*	±8.6
Ventilatory equivalent	30.9	34.8	31.4	36.8	31.2	40.7	39.3	35.5	33.3	4.15	35.7
	±2.2	±4.4	±5.1	±4.3	±3.8	±5.7	±4.0	±1.4	±6.2	****	±5.6
O_2-pulse (ml·$beat^{-1}$)	10.3	9.3	10.6	9.5	10.7	8.1	7.6	8.9	8.0	4.30	8.8
	±0.7	±1.5	±2.6	±2.7	±1.0	±1.2	±1.4	±1.1	±1.0	****	±1.7

*$p<0.05$, ****$p<0.001$.

amongst the groups for the pre-exercise and maximum heart rates.

$\dot{V}_{O_2\,max}\,l\cdot min^{-1}$ was observed highest in javelin throwers (1.95) and lowest in handballers (1.45). But when it was expressed in $ml\cdot kg^{-1}\cdot min^{-1}$, long-distance runners were found to score the highest value (43.0), whereas the poorest scorers were the badminton players (34.4). The results of ANOVA show that the difference of $\dot{V}_{O_2\,max}$ in both of its terms, ventilatory equivalent and O_2-pulse were highly significant. The change of $\dot{V}E_{max}$ was at 5% level.

Since the mean age of different sports participants varied significantly, it was adjusted with the analysis of covariance (ANCOVA) considering age as a concomitant variable. The application of ANCOVA was justified for $\dot{V}_{O_2\,max}\,l\cdot min^{-1}$ and O_2-pulse only. On the basis of significance, obtained from the result of ANOVA or ANCOVA, pairwise comparisons between two means were made and the levels of significance for $\dot{V}_{O_2\,max}$ are given in Table 2. No significant difference was observed amongst runners, sprinters, jumpers, and javelin throwers for their age-adjusted means of $\dot{V}_{O_2\,max}\,l\cdot min^{-1}$, but each of the groups was significantly superior to basket- and handball players. The basketballers, handballers, badminton players, and swimmers did not differ significantly with each other for this measurement. Means of badminton players and swimmers were significantly lower than those of javelin throwers and long-distance runners. When $\dot{V}_{O_2\,max}$ was expressed in $ml\cdot kg^{-1}\cdot min^{-1}$ each group of long-distance runners, sprinters, pentathletes, jumpers, and javelin throwers was found significantly superior to basketballers, handballers, badminton players, and swimmers. The former groups of athletes did not differ significantly with each other except for the pair of long-distance runners and jumpers. The latter groups were also well comparable with each other.

The mean values of $\dot{V}E_{max}$ for swimmers were significantly lower as compared to sprinters, jumpers, javelin throwers, and basketballers. Significantly higher values were obtained by jumpers than handballers and badminton players. The rest of the differences amongst each other were non-significant.

For O_2-pulse, 13 pairs out of 36 differed significantly from each other. Javelin throwers exhibited significantly higher values than each of the group of sprinters, basketballers, handballers, badminton players, and swimmers (5 pairs). Long-distance runners, like javelin throwers, also had significantly higher values than the above-mentioned groups except for sprinters (4 pairs). Both sprinters and jumpers were significantly superior to each group of basketball and handball players (4 pairs).

In comparison with the rest of the groups, long-distance runners, pentathlons, javelin throwers, and swimmers showed more economic ventilation as reflected by their lower $\dot{V}E_{max}/\dot{V}_{O_2\,max}$ ratio.

$\dot{V}_{O_2\,max}\,l\cdot min^{-1}$ was found to be significantly positively correlated with age, height, weight and BSA in these groups of girl athletes, trained in different events (Figs. 1–4).

Prediction equations for predicting $\dot{V}_{O_2\,max}\,l\cdot min^{-1}$ from physical characteris-

Table 2. Pairwise comparisons showing the level of significance for the mean differences of maximal oxygen consumption in female athletes of different sports activities.

		Long-distance running	Sprint	Pentathlon	Jumping	Javelin	Basketball	Handball	Badminton	Swimming
Long-distance running	$\dot{V}_{O_2 max}$ ($l \cdot min^{-1}$)		NS	NS	NS	NS	$p<0.005$	$p<0.005$	$p<0.05$	$p<0.025$
	$\dot{V}_{O_2 max}$ ($ml \cdot kg^{-1} \cdot min^{-1}$)		NS	NS	$p<0.05$	NS	$p<0.0005$	$p<0.0005$	$p<0.0005$	$p<0.0005$
Sprint	$\dot{V}_{O_2 max}$ ($l \cdot min^{-1}$)			NS	NS	NS	$p<0.01$	$p<0.01$	NS	$p<0.05$
	$\dot{V}_{O_2 max}$ ($ml \cdot kg^{-1} \cdot min^{-1}$)			NS	NS	NS	$p<0.0005$	$p<0.005$	$p<0.0005$	$p<0.0005$
Pentathlon	$\dot{V}_{O_2 max}$ ($l \cdot min^{-1}$)				NS	NS	NS	NS	NS	NS
	$\dot{V}_{O_2 max}$ ($ml \cdot kg^{-1} \cdot min^{-1}$)				NS	NS	$p<0.005$	$p<0.05$	$p<0.005$	$p<0.025$
Jumping	$\dot{V}_{O_2 max}$ ($l \cdot min^{-1}$)					NS	$p<0.025$	$p<0.01$	$p<0.05$	NS
	$\dot{V}_{O_2 max}$ ($ml \cdot kg^{-1} \cdot min^{-1}$)					NS	$p<0.005$	$p<0.05$	$p<0.005$	$p<0.025$
Javelin	$\dot{V}_{O_2 max}$ ($l \cdot min^{-1}$)						$p<0.0005$	$p<0.0005$	$p<0.01$	$p<0.005$
	$\dot{V}_{O_2 max}$ ($ml \cdot kg^{-1} \cdot min^{-1}$)						$p<0.005$	$p<0.025$	$p<0.005$	$p<0.025$
Basketball	$\dot{V}_{O_2 max}$ ($l \cdot min^{-1}$)							NS	NS	NS
	$\dot{V}_{O_2 max}$ ($ml \cdot kg^{-1} \cdot min^{-1}$)							NS	NS	NS
Handball	$\dot{V}_{O_2 max}$ ($l \cdot min^{-1}$)								NS	NS
	$\dot{V}_{O_2 max}$ ($ml \cdot kg^{-1} \cdot min^{-1}$)								NS	NS
Badminton	$\dot{V}_{O_2 max}$ ($l \cdot min^{-1}$)									NS
	$\dot{V}_{O_2 max}$ ($ml \cdot kg^{-1} \cdot min^{-1}$)									NS
Swimming	$\dot{V}_{O_2 max}$ ($l \cdot min^{-1}$)									
	$\dot{V}_{O_2 max}$ ($ml \cdot kg^{-1} \cdot min^{-1}$)									

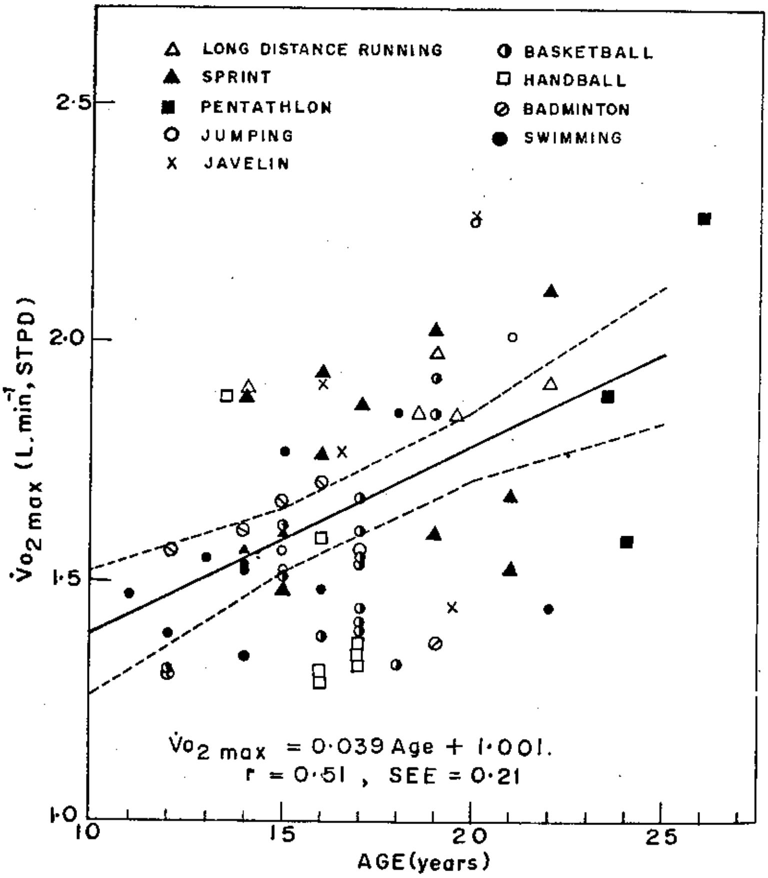

Fig. 1. Relationship of maximal oxygen uptake ($\dot{V}_{O_2\,max}$) to age in a group of girl athletes trained in different events.

tics were derived for sprinters, basketballers, swimmers i.e. the only groups having 10 or more subjects and for all nine events combined. The stepwise regression method was used to select the best predictor, next best predictor, and so on until all significant predictor variables were included. The prediction formulae with multiple correlation coefficients (R), coefficients of determination (R^2) and standard errors of estimate (S.E.E.) are listed in Table 3. R^2 for all the equations was significant.

Table 4 represents a comparative account of $\dot{V}_{O_2\,max}\,ml\cdot kg^{-1}\cdot min^{-1}$ investigated by present and foreign authors. It shows that all the mean values of different events reported elsewhere by other investigators exceeded our observed mean values except for McArdle *et al.* (1971) and Sinning and Adrian (1968).

The present study derived prediction equations to predict $\dot{V}_{O_2\,max}\,l\cdot min^{-1}$ from physical characteristics in different groups of girl athletes. Using stepwise regression

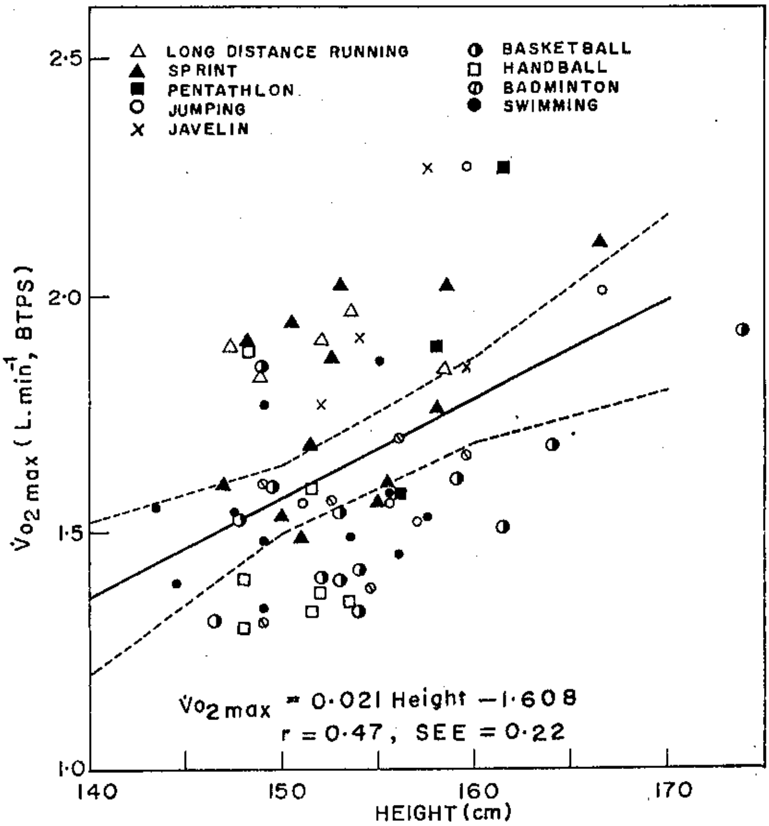

Fig. 2. Relationship of maximal oxygen uptake ($\dot{V}_{O_2 \max}$) to height in a group of girl athletes trained in different events.

method, the best predictor variables were considered. Weight was noted to be the best predictor in sprinters, BSA in swimmers, weight and age in basketball players, while weight, age, and height in the groups of all the girl athletes. All the equations were reliable. The values of multiple correlation coefficients (R) were found to vary from 0.60 to 0.92 and the standard errors of estimate (S.E.E.) were acceptably small, ranging from 5 to 10% of the mean values.

DISCUSSION

The aerobic capacity scores of the different groups of girl athletes of the present study when expressed in absolute value, were found to be much less than their counterparts of more-developed countries like Japan (FOX *et al.*, 1969; MIYASHITA *et al.*, 1970; MATSUI *et al.*, 1972), Czechoslovakia (SPRYNAROVA and PARIZKOVA, 1969), America (SINNING and ADRIAN, 1968; MCARDLE *et al.*,

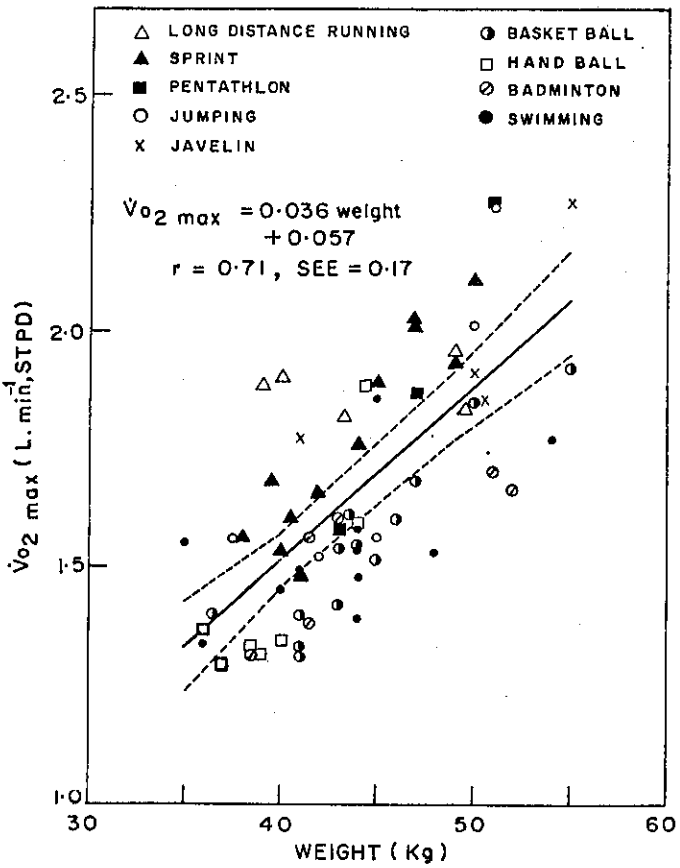

Fig. 3. Relationship of maximal oxygen uptake ($\dot{V}_{O_2 max}$) to weight in a group of girl athletes trained in different events.

1971), Sweden (HERMANSEN and ANDERSEN, 1965; SALTIN and ÅSTRAND, 1967), and France (JOUSSELLIN *et al.*, 1984). The lower aerobic power of the present subjects was expected largely due to their anthropometric shortcomings, lack of proper training, and/or genetic variation.

When expressed per kg body weight, mean $\dot{V}_{O_2 max}$ value of the Bengalee swimmers were well matched with that of Japanese and Czechoslovakian swimmers (FOX *et al.*, 1969; MATSUI *et al.*, 1972; SPRYNAROVA and PARIZKOVA, 1969) after correlation for ergometer. They used treadmill while we followed bicycle ergometer. $\dot{V}_{O_2 max}$ was reported 20% higher on the treadmill than on the bicycle ergometer (HARRISON *et al.*, 1980; CHATTERJEE and CHAKRAVARTI, 1986). The American basketball players who were studied by MCARDLE *et al.* (1971) and by SINNING and ADRIAN (1968) scored 35.7 and 34.4 $ml \cdot kg^{-1} \cdot min^{-1}$, respectively (at the beginning of the season), which were comparable with that achieved by our

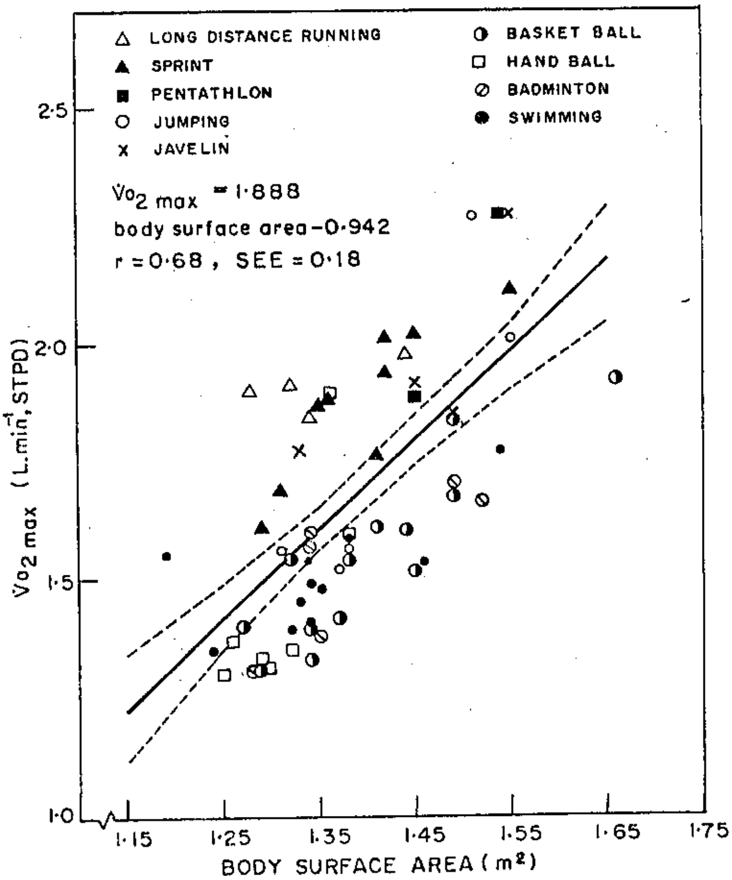

Fig. 4. Relationship of maximal oxygen uptake ($\dot{V}_{O_2\,max}$) to BSA in a group of girl athletes trained in different events.

basketballers (34.9 ml·kg^{-1}·min^{-1}). However, HOLMER *et al.* (1974) observed much higher values on their Swedish swimmers, which might be attributed to the fact that most of their swimmers were trained in middle and long distances while almost all of our swimmers were sprinters. Japanese swimmers (MIYASHITA *et al.*, 1970), French long-distance runners, sprinters, pentathletes, and basketballers (JOUSSELLIN *et al.*, 1984), Swedish girl athletes (HERMANSEN and ANDERSEN, 1965; SALTIN and ÅSTRAND, 1967) also exhibited $\dot{V}_{O_2\,max}$ values that were much superior to those of their Bengalee counterparts in the respective event. The probable reason for this is that their subjects were either top-grade or international or world elites or olympiads. Thus it may be concluded that the levels or standards of athletes greatly influence their $\dot{V}_{O_2\,max}$ ml·kg^{-1}·min^{-1} rather than ethnicity and overall dietary superiority, if any. DIPRAMPERO *et al.* (1970) observed no ethnic differences in maximal aerobic power between White and Negro athletes. LEARY

Table 3. Prediction formulae for predicting $\dot{V}_{O_2\,max}$ from physical characteristics in female athletes of different sports activities.

		Coefficients of							
		Age (year)	Height (cm)	Weight (kg)	Body surface area (m^2)	Constant	R	R^2	S.E.E.
Sprint	$\dot{V}_{O_2\,max}$ ($l \cdot min^{-1}$)	—	—	0.049	—	−0.340	0.88	0.77****	0.11
Basketball	$\dot{V}_{O_2\,max}$ ($l \cdot min^{-1}$)	0.018	—	0.034	—	−0.253	0.92	0.84****	0.08
Swimming	$\dot{V}_{O_2\,max}$ ($l \cdot min^{-1}$)	—	—	—	0.958	0.245	0.60	0.36*	0.13
All nine events combined	$\dot{V}_{O_2\,max}$ ($l \cdot min^{-1}$)	0.029	−0.008	0.037	—	0.742	0.78	0.61****	0.16

R, multiple correlation coefficient; R^2, coefficient of determination; S.E.E., standard error of estimate. Level of significance of R^2 is shown by asterisks: *$p<0.05$, ****$p<0.001$.

Table 4. A comparative account of $\dot{V}_{O_2\,max}$ investigated by present and foreign authors.

Nationality	Event	Level	No.	$\dot{V}_{O_2\,max}$ ($ml \cdot kg^{-1} \cdot min^{-1}$)	Ergometer	Reference
Japanese	Swimming		20	40.9	Treadmill	Fox *et al.* (1969)
Japanese	Swimming		13	40.6	Treadmill	Matsui *et al.* (1972)
Czechoslovakian	Swimming		10	45.9	Treadmill	Sprynarova and Parizkova (1969)
Indian (Bengal, eastern zone of India)	Swimming	National and State	11	36.03	Bicycle	Present study
American	Basketball	Intercollegiate	6	35.7	Treadmill	McArdle *et al.* (1971)
American	Basketball	Intercollegiate	7	34.4	Bicycle	Sinning and Adrian (1968)
American	Basketball	Intercollegiate	15	49.6	Treadmill	Vaccaro *et al.* (1979)
Indian (Bengal, eastern zone of India)	Basketball	National, State, Intercollegiate and Interschool	13	34.86	Bicycle	Present study
French	Long-distance running (800–1500 m)	French Top Athletes	13	59.2	Jaeger Treadmill	Jousselin *et al.* (1984)
Indian (Bengal, eastern zone of India)	Long-distance running (800–1500 m)	National, State, Intercollegiate and Interschool	5	43.7	Bicycle	Present study
French	Sprint (100–200 m)	French Top Athletes	13	52.9	Jaeger Treadmill	Jousselin *et al.* (1984)
Indian (Bengal, eastern zone of India)	Sprint (100–200 m)	National, State, Intercollegiate and Interschool	13	40.70	Bicycle	Present study
French	Pentathlon	French Top Athletes	6	55.5	Jaeger Treadmill	Jousselin *et al.* (1984)
Indian (Bengal, eastern zone of India)	Pentathlon	National, State and Intercollegiate	3	40.30	Bicycle	Present study

and WYNDHAM (1965) also did not find any difference between Caucasian and Bantu athletes. We observed exactly the identical mean value for HR_{max} in swimmers (197 beats·min^{-1}) as reported by KRAMER and LEURIE (1964) on their American swimmers. SALTIN and ÅSTRAND (1967) obtained 204 beats·min^{-1} for their one female swimmer. The mean HR_{max} (191 beats·min^{-1}) achieved by the American basketballers (MCARDLE *et al.*, 1971) was more or less similar with that obtained in the present study (192 beats·min^{-1}), but was found to be lower as reported by SINNING and ADRIAN (1968).

The inter-event comparison shows that the long-distance runners were superior to all categories of sports participants for their $\dot{V}_{O_2 max}$ ml·kg^{-1}·min^{-1}. Similar results were obtained by CERRETELLI and RADOVANI (1960), DIPRAMPERO *et al.* (1970), JOUSSELLIN *et al.* (1984). According to SALTIN and ÅSTRAND (1967), various inter-dependent factors like energy output (from aerobic and anaerobic processes), neuromuscular function (strength and technique), and psychological factors influence the physical performance. These factors play quite different roles in various sports events. The maximal oxygen intake is a measurement of the maximal motor power by aerobic processes. The aerobic work capacity, thus, is a dominant factor for good performance in endurance events like long-distance running. Thus, maximal value of $\dot{V}_{O_2 max}$ ml·kg^{-1}·min^{-1} was attained by long-distance runners. JOUSSELLIN *et al.* (1984) were also of the same opinion that sports with high energy requirements showed high $\dot{V}_{O_2 max}$ ml·kg^{-1}·min^{-1}. The present study noted that the $\dot{V}_{O_2 max}$ ml·kg^{-1}·min^{-1} of swimmers was relatively low (36.0), which is in agreement with earlier data (CERRETELLI and RADOVANI, 1960; DIPRAMPERO *et al.*, 1970). The body weight of swimmers being supported by water displacement, they do not have to work against gravity. They only overcome the frictional resistance. The technique in swimming is also of great importance. The resistance to progression depends very much on the position of the floating body (DIPRAMPERO *et al.*, 1970). Moreover, almost all of our swimmers were trained for sprint. No significant difference was observed between the two team sports (basketball and handball players) for their $\dot{V}_{O_2 max}$ ml·kg^{-1}·min^{-1}. This is possibly due to certain similarities in the physiological demand by them, particularly a demand of vigorous energy expenditure for repeated short bursts throughout the game. In team sports, there is a correspondence between the level of $\dot{V}_{O_2 max}$ ml·kg^{-1}·min^{-1}, the size of the ground play, and the distance covered by the players during the match. Amongst the handball players, the lowest value was scored by the goalkeeper, a position where aerobic power would be of minimal importance. This result is concomitant with the findings of WITHERS and ROBERTS (1981), who obtained lowest value for the goalkeeper of final hockey team. SHEPHARD (1978) reported that in basketballers, the aerobic capacity is typically low in both absolute and relative terms, which is in accordance with the present observation. This is due to the fact that according to the design of the play, they depend heavily on anaerobic work (SELIGER *et al.*, 1972). All groups of girl athletes of the present study showed their significant superiority for aerobic capacity over the untrained college women investigated by CHATTERJEE and CHAKRAVARTI (1986) on bicycle ergometer in our laboratory, which indicates the beneficial effect of any type of physical training on maximum aerobic capacity. In this investigation, $\dot{V}_{O_2\,max}\,l\cdot min^{-1}$ was found to have significant positive correlations with physical characteristics in the girl athletes trained in different events. Physiologically, the aerobic capacity is indicative of the functional state of the respiratory, circulatory, and metabolic systems. The greater the capacity of the dimensional and functional factors of these systems, the higher the aerobic capacity.

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