PHYSIOLOGICAL PROBLEMS EXPECTED AT THE MEXICO CITY OLYMPIC GAMES

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There is a growing realization among medical men associated with athletics and other sports that the physical environment (comprising air temperature, relative humidity, air movement and altitude above sea-level) in which athletics events are carried out can affect performances and even constitute a danger to life. Sir Adolphe Abrahams[1] states that he knows of at least one death from heat stroke in an athletic event on a very hot and humid day. We have no doubt that if rectal temperatures were measured immediately after sudden unexplained deaths in sporting events, a much larger number of heat-stroke deaths would have been shown. Recent reports in papers on the deaths from heat stroke of young army recruits carrying out exercises at a high level of work on very hot days, lend support to this argument.

The next Olympic Games are due to be held in Mexico City at an altitude of 7,000 feet above sea-level. There is much concern in international athletic circles on the possible effect that this altitude might have on the performances of the athletes and, also, as to whether there might not be some danger to life. With these questions in mind, a Symposium was held in December 1965 at Magglinen in Switzerland on the 'Effects of medium altitude on athletic performances' to which exercise-physiologists, including those from this laboratory, were invited.

The altitude of Johannesburg is 5,780 feet (1,760 metres) and therefore a study of the physiology of exercise and of the performances of athletes at this altitude compared with sea-level will give some information on the limitations imposed on athletic performances by 'medium' altitudes.

In this paper is described the oxygen consumption/ventilation (BTPS) relationship during physical activities in Johannesburg and this relationship is compared with that obtaining at sea-level. The results are also given of studies of the maximum oxygen intakes and pulmonary ventila-

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tions of 10 national and international class athletes studied in Johannesburg and a comparison of these results is made with Astrand's observations on similar grade athletes studied at sea-level.[3]

The performances of sprinters and distance athletes at sea-level and at Johannesburg are compared in a separate paper.[6]

METHODS

The procedures used for the measurement of pulmonary ventilation and of maximum oxygen intake are described in detail in papers from this laboratory.[4,5,7] The subjects had physical characteristics as shown in Table I.

TABLE I. CAUCASIAN AND BANTU ATHLETES COMPARED WITH FIT YOUNG MEN

	Age (years)	*Height (cm.)*	*Weight (kg.)*
Caucasian athletes			
1. Richard C.	18	172·1	68·3
2. John V.	20	176·5	72·3
3. Wilhelm O.	28	179·0	62·3
4. Perry L.	24	184·1	67·3
Mean	23	177·9	67·5
Bantu athletes			
5. Daniel M.	33	—	50·5
6. John Q.	24	167·5	58·9
7. Benoni M.	23	177·7	69·6
8. Bennet M.	29	166·8	55·0
9. Humphrey K.	26	163·2	61·4
10. Thomas K.	23	163·2	55·2
Mean	25	167·7	58·4
Fit, young men			
Caucasian (N = 35)	19	175·9	71·8
Bantu (N = 88)	Young adults (No registration of births)	165·9	59·1

RESULTS

Pulmonary Ventilation

The pulmonary ventilations in l./min. (BTPS) of some 35 Caucasians and 88 Bantu who carried out the step test at four rates, were plotted against oxygen consumptions. Separate regression lines were fitted to the data for the Caucasians and the Bantu and these lines are shown in Fig. 1. The 83% confidence limits are relatively wide, compared with those fitted to the regression lines of oxygen consumption against work rate, and overlap throughout, so that it can be concluded that the pulmonary ventilations of Caucasians and Bantu during physical effort at an altitude of 6,000 feet are not significantly different. The 'ventilatory equivalent'—the pulmonary ventilation (BTPS)/litre per min. of oxygen consumption—is approximately 30 litres.

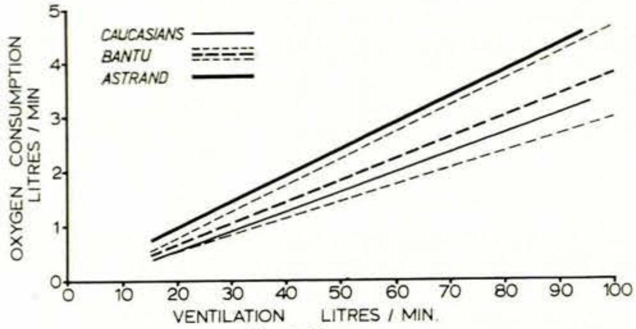

Fig. 1. See text.

Astrand's[2] regression line for ventilation against oxygen consumption at sea-level is also shown in Fig. 1. The ventilatory equivalent from this regression line is about 20 l./min. It can be concluded therefore that the ventilatory equivalent at 6,000 ft. altitude is about 50% greater than it is at sea-level.

Maximum Oxygen Intake

Caucasian athletes were significantly taller than the Bantu, with mean heights of 177·9 cm. and 167·7 cm., respectively (Table I). The Caucasians were also significantly heavier, with a mean weight of 67·5 kg. compared with the 58·5 kg. of the Bantu (Table I).

The mean maximum oxygen intake of the Caucasians was 4·13 l./min. and this is significantly greater than the mean of the Bantu athletes, 3·69 l./min. However, when these figures are expressed per kg. of body-weight—the correct basis for comparing samples of different weight—the mean maximum oxygen intakes of Caucasians and Bantu athletes are similar, being 61·1 and 63·2 ml./kg./min. respectively (Table II).

The mean ventilations (BTPS) of the 2 groups at their respective maximal levels of exercise are not significantly different.

DISCUSSION

In Fig. 1, it is shown that pulmonary ventilation was markedly increased during physical effort in Johannesburg.

TABLE II. BANTU AND CAUCASIAN ATHLETES COMPARED

Subjects	*Max. HR (beats/min.)*	*Pulm. vent. l./min.*	*Pulm. vent. BTPS*	*Max. oxygen l./min.*	*Max. oxygen ml./kg./min.*	*Performance*
1. Richard C.	192	—	140·8	4·07	59·6	Fastest 500 yard swim at 6,000 ft. altitude.
2. John V.	192	—	163·2	4·31	59·6	½ mile—1 min. 53 sec.
3. Wilhelm O.	168	—	143·3	3·97	63·7	1 mile—4 min. 8 sec. 2 miles—8 min. 53 sec. 3 miles—13 min. 38 sec.
4. Perry L.	190	—	152·3	4·16	61·9	1 mile—4 min. 11 sec. 3 miles—14 min. 28 sec.
Mean	186		149·9	4·13	61·2	
5. Daniel M.	190	—	141·6	3·40	67·3	3 miles—14 min. 11 sec. 6 miles—29 min. 23 sec.
6. John Q.	192	—	151·4	3·84	65·2	½ mile—1 min. 52 sec. 1 mile—4 min. 12 sec.
7. Benoni M.	192	—	160·5	3·90	60·4	½ mile—1 min. 48·7 sec.
8. Bennet M.	204	—	142·6	3·37	61·3	2 miles—9 min. 14·8 sec. 3 miles—14 min. 14·7 sec.
9. Humphrey K.	204	—	163·8	3·46	56·4	½ mile—1 min. 48·7 sec.
10. Thomas K.	204	—	135·9	3·80	68·7	2 miles—9 min. 20 sec. 3 miles—14 min. 19·8 sec.
Mean	198		149·5	3·69	63·2	

From this figure it can be estimated that a man running at a maximum oxygen intake of 4·0 l./min. at sea-level will have a pulmonary ventilation of 100 l./min. When he runs in Johannesburg the same pulmonary ventilation will give him an oxygen consumption of only 3·0 l./min. This level of oxygen intake would certainly not be sufficient for him to run his race at the same pace as at sea-level. If he is to increase his pulmonary ventilation in Johannesburg to give an oxygen consumption of 4·0 l./min. (which might be essential to achieve the same time for the event as at sea-level) then he would require a pulmonary ventilation of 130 l./min. The higher level of pulmonary ventilation might cause pulmonary distress and force the man to reduce his speed.

It could be argued that the air is less dense at the altitude of Johannesburg and that this would allow the man to increase his pulmonary ventilation without the distress that the same increase would occasion at sea-level. This hypothesis, however, needs to be tested by experimentation.

There is indirect evidence that the increased pulmonary ventilation at medium altitude decreases the *maximum* oxygen intake. In Johannesburg the mean maximum oxygen intake of the athletes was found to be 62·2 ml./kg./min. (mean pulmonary ventilation 149·4 l./min.) compared with the sea-level value of Astrand's athletes,[3] a mean maximum oxygen intake of 72·8 ml./kg./min. (with a mean pulmonary ventilation of 119·8 l./min).

From this evidence it may be concluded that performances at the altitude of Mexico City would be markedly affected, but that there is little possibility of danger to life.

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