Capacity for physical work of Bantu recruits weighing less than 50 kg

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SYNOPSIS

The maximum oxygen intakes of samples of about 30 Bantu, weighing less than 50 kg from different tribal groups (Zulu, Xhosa, Sotho and Shangaan) were measured on a treadmill. The mean maximum oxygen intake of the 164 men was 2,12 litres/min and only 18 men (11 per cent of the sample) had maximum oxygen intakes of 2,5 litres/min or above (the minimum requirement for such tasks as shovelling rocks and tramming it).

The samples of the different tribes differ in age, but when the age effect is taken into account then there were *no significant differences between tribes in maximum oxygen intakes.*

An incidental finding was that both age and body weight correlated significantly with the maximum oxygen intakes of these underweight subjects. Not one of the subjects who weighed less than 45 kg or who was older than 40 years had maximum oxygen intakes high enough to permit their being able to do strenuous work underground. It is clear therefore that Bantu who weigh less than 45 kg or are older than 40 years should *not be employed on such strenuous tasks as shovelling rock and tramming it.*

INTRODUCTION

In a previous paper from this Laboratory the energy costs of various underground tasks were given[2]. Shovelling rock and tramming it, the most strenuous tasks, were shown to have mean oxygen consumptions of 1,39 and 1,27 litres/min respectively. It is well attested in the physiological literature that in order to carry out sustained work at such rates of oxygen consumption men require maximum oxygen intakes of at least double these values. The mean maximum oxygen intake of the average new Bantu recruits is 2,63 litres/min[10] and only 30-40 per cent of new recruits have high enough maximum oxygen intakes for these more strenuous physical tasks. Hence in the interest of the recruits, in preventing them from being put onto tasks for which they do not have sufficiently high physical work capacities, and of mine management, so that they can set realistic production standards, it was recommended that new recruits to the mines be tested and classified in terms of their capacities for physical work[2] and these tests are being used extensively in the gold mining industry today.

Research on the maximum oxygen intakes of Bantu recruits had shown that there was a significant correlation between oxygen intake and body weight[9]. Heavier men have higher maximum oxygen intakes and vice-versa. In an internal Chamber of Mines research report (1965) it was shown, further, that, because of this correlation between maximum oxygen intake and body weight, only one in five Bantu recruits who weigh less than 50 kg have maximum oxygen intakes of 2,5 litres/min or above. This is the minimum requirement for such strenuous underground tasks as shovelling rock and tramming it. It was, therefore, recommended that recruits who weigh less than 50 kg should not be employed on these tasks. However, the sample of underweight men upon which this conclusion was based was rather small and it is important to validate the conclusions on a larger sample of Bantu recruits weighing less than 50 kg. This validation is one of the objects of this paper.

It has also been claimed in certain quarters of the mining industry that these weight and maximum oxygen intake limits do not apply to certain tribal groups. In order to test this assertion the maximum oxygen intakes were measured of samples of 30 men, weighing less than 50 kg, from most of the main tribal groups in the mines (Zulu, Sotho, Xhosa and Shangaan).

This paper contains the conclusions reached on these two aspects of the study.

METHOD

About 30 members of each of the major tribal groups working in the gold mining industry and each weighing less than 50 kg were used in this study. The age of each individual was obtained by questioning and his weight and height measured. Body surface area was determined in the photodermoplanimeter according to the procedure developed by van Graan[7].

Maximum oxygen intake was determined on the treadmill set at a slope of 2,5 degrees. This was done over a two-day period and according to the standard procedures developed and adopted by this Laboratory[8]. The averages of the two highest values of heart rate and oxygen intake were taken as representing maximum values.

RESULTS

The mean maximum oxygen intake of the 164 men, comprising all the various groups of underweight Bantu,

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was 2,12 litres/min with a standard deviation of 0,30 litre. Only 11 per cent of the total sample was found to have maximum oxygen intakes of 2,5 litres/min and above.

The mean values obtained on the different tribal groups with respect to age, weight, height, resting rectal temperature, maximum heart rate, maximum lung ventilation, maximum oxygen intake (in litres/min) and millilitres of oxygen per kilogram of body weight and body surface area and the standard deviations of these values, are given in Table I. The 13 Pondo, 4 Zulu and 2 Hlubi subjects were grouped together because the number of underweight men from each of these tribes was very small.

To test for any significant difference (at the 95 per cent level of confidence) between the mean values of age, weight, etc., of men from the various tribes the Scheffe method of multiple comparisons was used. This method only indicates the existence of significant differences between groups but does not specify which groups are different from one another. The results of these analyses are presented in Table II which shows that there were significant differences in ages, resting rectal temperatures and maximum oxygen intakes.

Having demonstrated that there were significant differences in the mean maximum oxygen intakes of the various tribal groups, a more detailed comparison of the tribal groups was carried out and this showed that:-

(a) With one exception there was no significant difference between the mean values for the Tswana, Malawi, Pondo-Hlubi-Zulu, Basuto and Xhosa groups; the exception being that the mean value for the Tswana group was significantly higher than that of the Xhosa group.

(b) The mean maximum oxygen intake of the Shangaan group was significantly lower than those of the Tswana, Malawi and Pondo-Zulu-Hlubi groups.

(c) There were no significant differences between the mean maximum oxygen intakes of the Shangaan, Xhosa and Basuto groups.

(d) The above picture did not change at all when the maximum oxygen intake was expressed in millilitres of oxygen per kilogram of body weight per minute.

The differences observed between resting rectal temperatures of the men from the various tribal groups were so small and their contributory value to maximum oxygen intake so insignificant that no further analyses were done upon this point.

Maximum oxygen intake are plotted against age in Fig 1, and the correlation coefficient between the measurements is 0,55, which is significant at the 5 per cent level. Plots of maximum oxygen intakes against weights are shown in Fig 2 and the correlation coefficient between them is 0,66. This correlation coefficient is significant at the 1 per cent level.

The total mean surface area of the subject, by direct measurement, was 1,62 m^2 with a standard deviation of 0,07.

DISCUSSION

The results obtained on 164 light-weight Bantu of various tribal origins showed that most of these light-weight men were not capable of doing even moderately hard work. Their average maximum oxygen intake value was 2,12 litres/min with a range of from 0,93 litres/min to 2,95 litres/min. Only 11 per cent of the men had maximum oxygen intakes of 2,5 litres/min (the minimum value required for such tasks as shovelling, tramming and tram-shovelling[2]) or above. This percentage is lower than that reported in 1965 when it was shown that one out of five underweight men (20 per cent) was capable of moderately hard work. However, the 1965 conclusions were based upon 27 men, none of whom weighed less than 45,5 kg, and it was stated that . . . . 'It would be wise to validate the results on a larger sample of men'. The present observations include those on 34 men who weighed less than 45,5 kg and if these are excluded the percentage of underweight men with maximum oxygen intakes above 2,5 litres/min is increased to 14 per cent.

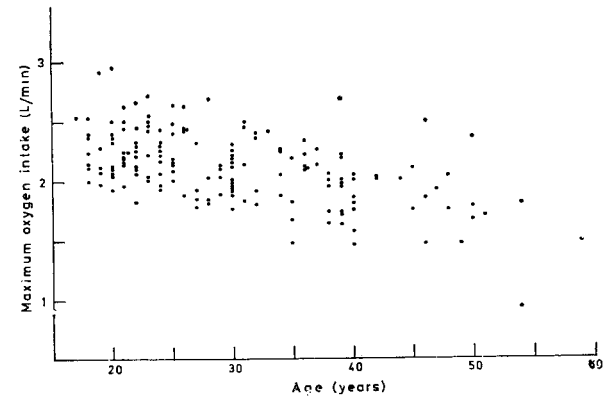

Fig. 1—Decrease of maximum oxygen intake with age

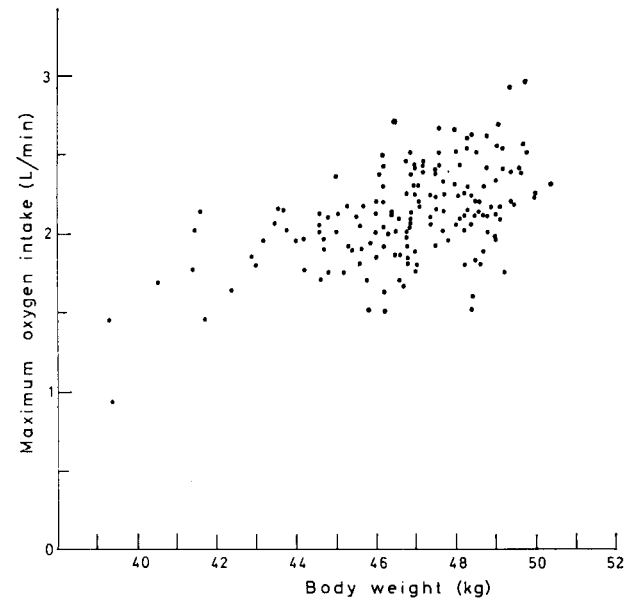

Fig. 2—The influence of body weight on maximum oxygen intake

TABLE I

MEANS AND STANDARD DEVIATIONS

	'N'	Age (years)		Weight (kg)		Height (cm)		R.R. Temp (°F)		Maximum Heart Rate (beats/min)		Maximum Vent. (litres)		Maximum 0_2 (litres)		Maximum 0_2 (ml/kg body weight)		Surf. Area (m^2)	
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Tswana	32	29,5	8,5	46,52	2,29	158,61	5,62	99,42	0,62	181,84	7,16	65,11	11,41	2,27	0,29	48,42	5,02	1,60	0,09
Malawi	32	24,6	5,9	47,28	1,65	155,63	4,10	99,29	0,72	181,94	8,22	64,99	8,49	2,18	0,27	46,03	5,04	1,66	0,06
Pondo Zulu Hlubi	19	32,0	11,1	46,81	2,15	157,94	3,42	98,76	0,77	183,00	12,58	66,62	10,68	2,17	0,34	46,19	5,95	1,62	0,06
Basuto	29	34,9	9,2	46,43	2,43	157,62	9,15	98,95	0,67	179,14	8,28	62,04	10,28	2,10	0,30	45,06	5,73	1,61	0,07
Xhosa	29	28,9	9,4	46,88	1,99	156,94	3,46	98,60	0,84	178,41	9,25	64,72	11,04	2,05	0,27	43,68	4,72	1,62	0,07
Shangaan	23	32,6	9,2	47,15	2,11	157,87	5,43	98,69	0,89	180,87	10,01	60,01	10,20	1,91	0,27	40,30	5,44	1,61	0,07

TABLE II

MULTIPLE COMPARISON OF MEANS USING SCHEFFE'S METHOD*

	Age (years)	Weight (kg)	Height (cm)	R.R. Temp (°F)	Max. Heart Rate (beats/min)	Max. Vent. (litres)	Maximum 0_2 (litres)	Max. 0_2 (ml/kg body weight)	Surf. Area (m^2)
F—Observed	4,26	1,07	1,41	4,54	0,83	1,08	4,00	5,95	1,70
95% F—Tables	2,26	2,26	2,26	2,26	2,26	2,26	2,26	2,26	2,26

The samples of the various tribal groups differed in age, but when the results are standardised for age, there were no differences between underweight men from the different tribal groups in maximum oxygen intake. The small differences observed between the maximum oxygen intakes of the various tribal groups were due to age and are therefore of no significance in regard to the recruitment, selection and placement of labour. An underweight Bantu will always have a low working capacity irrespective of his tribal origin. There is also no support in these results for the contention that underweight men of certain tribes have adequate physical work capacities for such hard-work tasks as high-speed development, etc. In fact, studies of heights and weights of different tribal groups showed that the concept that men of certain tribes are shorter but heavier than men of other tribes[3] is erroneous.

The study also brought out an unexpected, incidental finding. Age and body weight were shown to be major factors affecting maximum oxygen intake even amongst this selected group of underweight men. Their ages ranged from 17 to 59 years and the correlation coefficient between age and maximum oxygen intake was −0,55. This result, which is in line with those reported by Robinson[4], and Astrand *et al*[1] indicates conclusively that, even in this light-weight group, maximum oxygen intake decreases significantly with increase in age. The lowest maximum oxygen intake, 0,93 litre/min, was that of a subject who was 54 years of age and who weighed only 38,5 kg. In the light of related data[6] in which age was shown to be a causal factor in heat stroke and heat intolerance, it is of interest to note that not one subject aged 40 years or above had a maximum oxygen intake of 2,5 litres/min or above, the minimum required for moderately hard work underground. Maximum oxygen intake was also closely related to body weight, even in this underweight group. The lowest values were recorded on subjects weighing less than 40 kg and the highest values on men weighing 49-50 kg. Not one man of less than 45 kg in weight had a maximum oxygen intake above 2,5 litres/min. Such men should not be allocated to strenuous work. Furthermore, they should not be subjected to the present climatic room acclimatisation procedures[5] as they would be required to work at about 70 per cent of their maximum oxygen intakes. Their small body surface areas also count against them because it is impossible for them to lose heat fast enough to reject the high rates of heat production.

The general conclusion for this paper is that men who weigh less than 45 kg and are older than 40 years of age, irrespective of tribal group, should not be employed on such tasks as shovelling rock and tramming it because none of them are likely to have adequate physical work capacities for these more strenuous tasks.

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