MECHANICAL EFFICIENCY OF A CHAMPION WALKER*

C. H. WYNDHAM AND N. B. STRYDOM, *Human Sciences Laboratory, Chamber of Mines of South Africa, Johannesburg*

SUMMARY

Oxygen consumptions were measured on a champion walker, while walking at between 6·4 and 16·9 km/h and while running at between 11·3 and 17·7 km/h. Above 9·7 km/h the curve of oxygen consumption against speed for walking was almost twice as steep as that for running, indicating that even champion walkers are more efficient, mechanically, when running than when walking above 9·7 km/h. The curve for the champion walker was less steep than that for men walking in the normal way above 9·7 km/h indicating that the technique of 'rolling the pelvis' gives competition walkers greater mechanical efficiency. It was also found that the $V_{O_2.MAX}$ of the champion walker was higher when running than when walking.

Recent studies in this laboratory[1] have shown that there is a highly non-linear relationship between V_{O_2} and speed of walking between 6·4 and 8·1 km/h. The shape of the curve expressing this relationship is such that one can predict, by extrapolation of the curve to 9·7 km/h, that a man of average weight walking at this speed would have an oxygen consumption which would be equal to his $V_{O_2.MAX}$ or exceed it.

In athletic competitions, walkers often exceed this speed of walking for a period of an hour or so. In order to do this either they must have very much higher $V_{O_2.MAX}$ or they must have much lower V_{O_2} than the average individual, i.e. they must be mechanically much more efficient in their walking. It seems probable that the latter is the case because competitive walkers have a technique of walking in which they 'roll the pelvis'.

We decided to test the hypothesis that competitive walkers do not have abnormally high $V_{O_2.MAX}$ but are mechanically more efficient than ordinary individuals. Oxygen consumptions were measured on a South African champion walker while he was walking at 6·4, 8·1, 9·7, 11·3, 12·9, 13·7, 14·5, 16·1 and 16·9 km/h on the treadmill and also while he was running at 11·3, 12·9, 14·5, 16·1 and 17·7 km/h. The results are compared with those obtained on a sample of individuals, walking in the normal way, while they walked at 4·8, 6·4 and 8·1 km/h and ran at 9·7, 11·3 and 12·9 km/h.[1]

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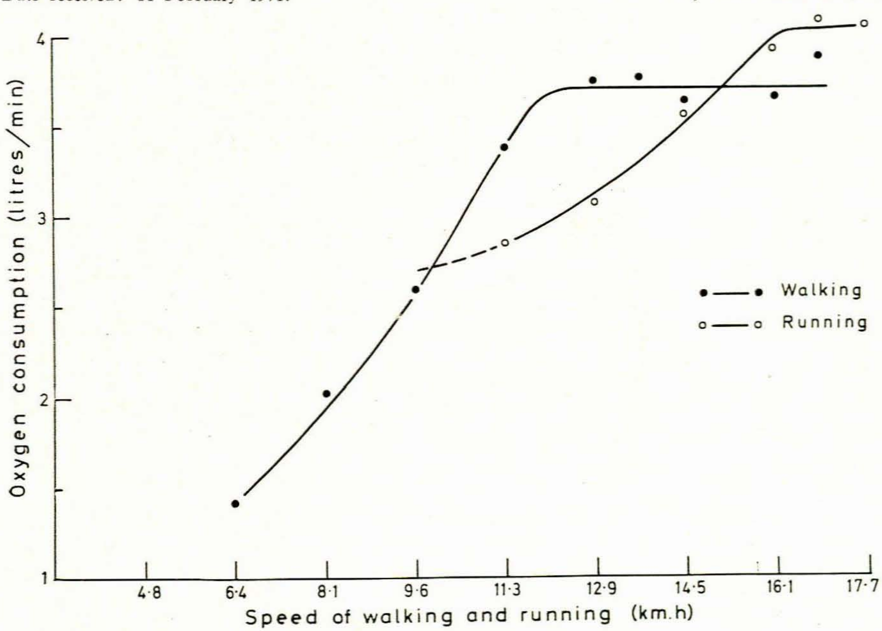

Fig. 1. Oxygen consumption plotted against speeds of running and walking by a champion walker.

METHODS

The studies were carried out on the treadmill at the Human Sciences Laboratory. The treadmill can be adjusted to run at any speed between 3·2 and 25·8 km/h. The speed-indicator was calibrated repeatedly during the study.

Oxygen consumptions were measured by collecting expired air through special low-resistance mouthpieces and valves into Douglas bags. The expired air volumes were metered in a Tissot spirometer and the oxygen concentration in an aliquot sample was analysed in a Beckman paramagnetic oxygen analyser. Two observers made one measurement on each sample in order to minimize observer errors.[2]

RESULTS

Oxygen consumption is plotted against speed in Fig. 1 both for walking at various speeds from 6·4 to 16·9 km/h and for running at

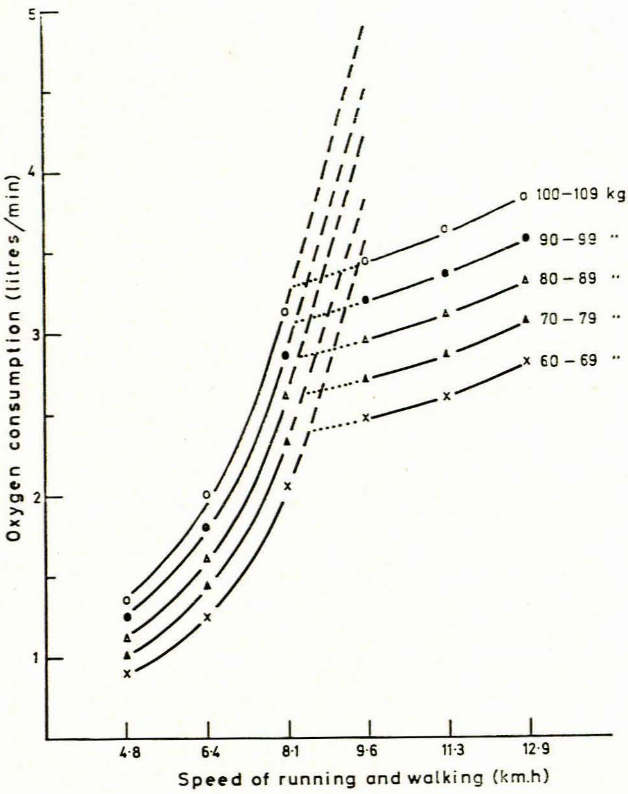

Fig. 2. Oxygen consumption plotted against speeds of running and walking by men grouped according to weight.

various speeds from 11·3 to 17·7 km/h. Fig. 1 shows the following: (*i*) the slope of the curve, fitted to oxygen consumption against speed, for walking is much steeper than that for running; (*ii*) the maximum oxygen intake for walking (3·70 litres/min) is lower than that for running (4·05 litres/min); and (*iii*) oxygen intakes for running at 11·3 and 12·9 km/h are lower than those for walking at these two speeds. Height and weight of the subject is given in Table I.

TABLE I. PHYSICAL CHARACTERISTICS

	Height (cm)	*Weight (kg)*	*Age (years)*
Champion walker	177·8	65·70	28
25 ordinary walkers[1]	179·8	77·95	30

DISCUSSION

The general shape of the curves of oxygen consumption against speed for walking and for running of the South African champion walker are similar to those published recently by this laboratory[1] on men walking in the normal way (Fig. 2). There is, however, one important difference. The curve for walking of the champion walker is less steep in slope than the curve of the ordinary individuals. This point is brought out in Fig. 3 where the curve for walking, of the 60 - 69-kg group from Fig. 2, is plotted together with that of the champion walker. This figure shows that up to 8·1 km/h there is essentially no difference in oxygen consumption between the champion and an ordinary individual of the same weight. However, at 9·7 km/h, the oxygen consumption of the champion walker is about 1·0 litre/min less than that 'predicted' for the individual (by extrapolation of the curve for oxygen consumption against speed of walking). At 11·3 km/h the difference would be even greater. The oxygen consumption of the champion walker was 3·36 litres/min, whereas extrapolation of the curve for walking of the ordinary individual to 11·3 km/h would give a ridiculously high value. The differences at 9·7 and 11·3 km/h between the oxygen consumption measured in the champion walker and those 'predicted' for an individual walking normally, are a measure of the tremendous improvement in mechanical efficiency that is obtained by the champion walker at speeds above 8·1 km/h by the technique of 'rolling the pelvis'.

That these levels of oxygen consumption, when walking at speeds between 6·4 and 16·1 km/h, are characteristic of competitive walkers is indicated in Fig. 4 where our values are compared with those given by Menier and Pugh[3] for four Olympic walkers. The mean maximum oxygen intake of the South African champion walker was 56 ml/kg/min which is somewhat lower than the mean of 60 ml/kg/min of the four Olympic walkers tested by Menier and Pugh. Their subjects, like ours, were studied at 1 800 m above sea-level (Johannesburg is at an altitude of 1 763 m above sea-level). A recent unpublished study of maximum oxygen intake when running on a treadmill in Johannesburg and immediately after descending to sea-level in a deep mine showed that the average maximum oxygen intake of 25 subjects decreased by 10%. We disagree with Menier and Pugh on one point, however. We found that the maximum oxygen of the champion walker was higher when he ran on the treadmill than when he walked on it (61·5 compared with 56·0 ml/kg/min), whereas Menier and Pugh's subjects all had higher maximum oxygen intakes when they walked. Pugh and Menier's nding is surprising in view of the fact that a greater muscle mass is generally employed in running than in walking.

When we compare the slopes of the curves for walking and for running of the champion walker in Fig. 1, it is clear that the slope of the curve for running is only about half as steep as that for walking. This indicates that even a champion walker is much less efficient when walking than when running. Consequently, the maximum oxygen intake is reached at much lower speeds when walking (12 km/h) than when running (16 km/h). A further point in this regard is that the curves for walking and running of the champion walker intersect at between 10 and 11 km/h which indicates that below these speeds the champion walker is more efficient when walking than when running, but above these speeds the converse is true. The speeds at which the transition occurs, from greater efficiency during walking to greater efficiency during running, are higher in our champion walker than those given by Menier and Pugh,[3] also for champion walkers, and by Margaria *et al.*[4] for men walking in the ordinary way. They state that the transition occurs at 8 km/h. However, we found this to be the case only in men engaged in ordinary walking,[1] as indicated in

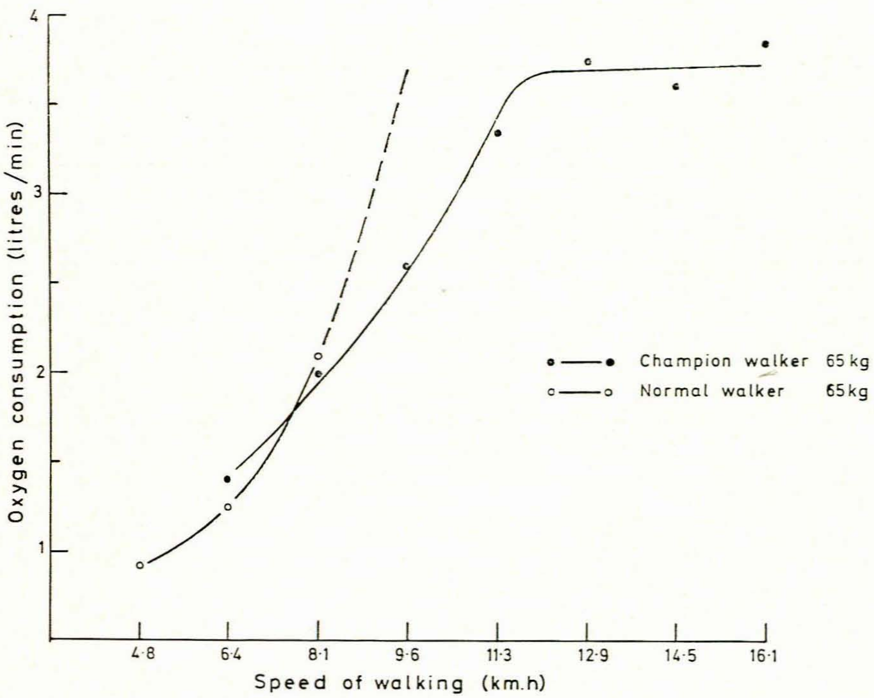

Fig. 3. Comparison of oxygen consumption against speed of walking by a champion walker and a normal walker.

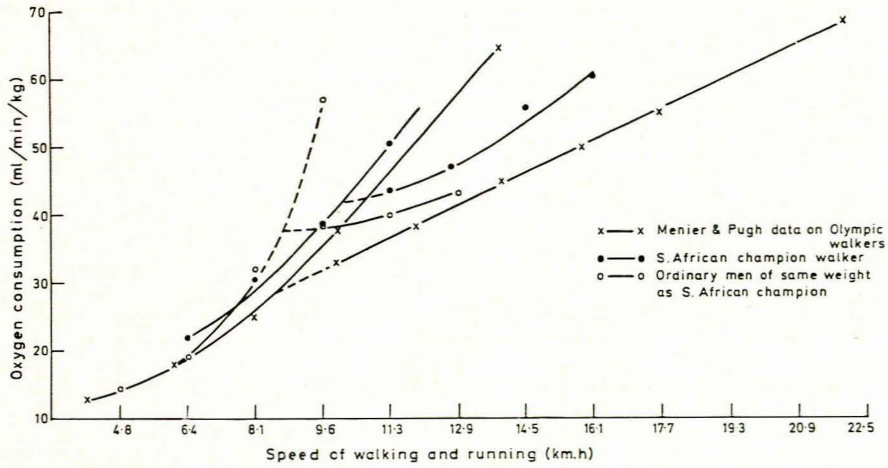

Fig. 4. Comparisons of oxygen consumption against speeds of walking and running by a champion walker, an ordinary walker, and Olympic walkers.

Fig. 4, but not in competitive walkers using the 'pelvic roll'.

There is a further way in which our study differs from that of Menier and Pugh. They compared the efficiency only of Olympic walkers when they walk and run. We have compared the efficiency of a champion walker with that of men walking in the ordinary way and, as shown in Fig. 3, there is no difference in oxygen consumption up to 8 km/h, but above that speed the oxygen consumption of the champion walker is very much lower than that 'predicted' by extrapolating the oxygen consumption/speed curves for walking in the ordinary way.

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