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PROGRESSIVE CHANGES IN ENERGY COST DURING A THREE-HOUR RACE-WALK EXERCISE

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ABSTRACT

Twenty experienced race-walkers were exercised in a controlled routine walking at 11.6 km/hr continuously for 3 hr, alternately on a treadmill and a cinder track. Analyses of expired air samples taken at 30 min intervals were used to calculate average R.Q. and energy expenditure. R.Q. was found to decrease progressively from 0.92 to 0.66 in the 3 hr and remained at this level 30 min later. The mean energy cost rose from 46.2 to 55.4 kJ/min or 24.7 to 29.7 kJ/min.m^2. The results indicate that this group probably experienced an elevation of aerobic activity as they utilized progressively more fat to satisfy metabolic demands and that R.Q. may be a good indicator for determining recovery after severe long duration exercise.

INTRODUCTION

During a series of studies into various anthropometrical and biomechanical measurements of competitive race-walk athletes we noticed that several of our subjects showed residual effects of fatigue in the days following very severe competitions. This raised discussion as to the energy expenditure involved in race-walking especially under the easily repeated conditions of training for these competitions. Since our athletes were very familiar with our laboratory procedures we began collecting information about their body weights and respiratory quotients before and after such exercise and came to the conclusion that we should design a specific experiment to gain insight to the energy levels involved in this sport. We chose a compromise between the two standard Olympic competition distances and a standard training walking-pace to suit the training programmes of our subjects. In order to provide suitable conditions both for our laboratory measurements and the walking exposure, the measured walk was divided into periods which began and ended on a treadmill with the intervening time spent walking on a nearby cinder track.

METHODS

Twenty national competition class race-walk men (ten 20 km specialists and ten 50 km specialists) were studied in a controlled routine lasting 4 hr which included time to take pre-exercise and 30 min post-exercise measurements. The total exercise routine comprised 3 hr divided into six 30 min periods of which the first and last were spent entirely on the treadmill. The other four were strictly regulated by stopwatch to control time taken to race-walk to and from the cinder track and for timed laps on the track, a total involvement of 20 min followed by 10 min on the treadmill. This routine necessitated careful preliminary practice by the subjects and was achieved during visits to the laboratory for other studies. The treadmill possessed a 3.15 m x 0.6 m horizontal walking surface. Its speed was held constant at 11.6 km/hr throughout the experimental period, this being the athletes' chosen training speed. This speed was also held remarkably accurately when walking on the track and to and from the treadmill.

Ventilation data were obtained before, after and while walking on the treadmill. The subjects used a noseclip and standard rubber mushroom-valved mouthpiece with a flexible coupling tube to a low resistance (100L) Kofranyi-Michaelis spirometer held by the observer and equipped with a sampling bladder and thermometer. This arrangement necessitated no interruption in the exercise for fitting the nosepiece and mouthpiece in place and the operator could control the instrument as well as prevent any further disturbance to the subject. 5 min expired air samples were taken during the last 6 min of time on the treadmill. The sample bladder's contents were analysed for CO_2 by infra-red analyser and O_2 by paramagnetic analyser set up in sequence with a single air pump. Ventilation samples were also obtained 30 min after the exercise routine. The respiratory quotient (R.Q.), corrected O_2 utilization and energy equivalents were calculated from the information obtained.

Heart rate was taken before, immediately after and 30 min after the exercise routine using the periodicity for 10 beats of the carotid pulse. Height and body weight were also measured from which to calculate surface area and additionally, body-weight was compared before and after the exercise routine. In both cases, as a part of standard procedure, the subject was carefully dry towelled, to remove surplus sweat before weighing. No food or water was taken during the 4 hr period.

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The data for each athlete were passed through a computer programme designed to calculate: corrected $\dot{V}_E$, 'true O_2' uptake, R.Q., O_2 calorific value and energy expenditure corrected for surface area. There were then averaged. The factor for correcting the expired air values was obtained from Carpenter (1968), 'true O_2' was calculated from the nomogram by Dill et al., and the surface area from the nomogram of Dubois & Dubois both of which are in Consolazio, Johnson & Pecora (1963). The calorific value of O_2 in kJ/LO_2 was derived from the equation: 19.606+ (R.Q. – 0.707)5.154 which is applicable within limits of R.Q. = 1.00 to 0.66. This information is also given in Åstrand & Rodahl (1978) and Documenta Geigy (1970).

DISCUSSION OF RESULTS

The results are given in the two tables. Table IB repeats the R.Q. values of Table II in order to allow immediate comparison with heart-rate and body-weight taken at the same times in the routine. The pre-exercise values for R.Q. were compared statistically in a paired 't' test with the ½ hr post-exercise resting values and were found to differ highly significantly, $P < 0.001$. It is also worth commenting on body weight loss given in Table IB. Compared to our expectations from occasional measurements taken at competitive events, we have not found a great weight loss and its significance as an index of recovery is reduced by post-exercise drinking. During competitive events race-walkers follow quite individual habits in drinking water; some drink nothing during the events and others drink plentifully. However, this varies considerably with climatic conditions, total distance and speed of walking. For this experimental study the weather conditions were uniformly pleasantly cool and the walking pace was 1 km/hr slower than the best of our athletes would expect to use in competition for 35 km.

The pace of 11.6 km/hr for 3 hr was designed to give a 'good' level of work but both the rates of O_2 uptake and the heart-rates at the point of stopping exercise, confirm that the exercise was submaximal. The average energy cost calculated from the values during the exercise routine was 50.5 kJ/min. This is less than 50% of Margaria's (1972) predicted maximum anaerobic capacity value based on 1.6 kJ/min.kg which for our

TABLE I

Summary of personal and other measurements of 20 race-walkers

TABLE IA

Age	30.0 yr ± 4.1 (22 – 42)
Height	178 cm ± 3.8 (172 – 187)
Weight	68.5 kg ± 3.1 (62.2 – 74.9)

Average surface area 1.867m²

TABLE IB

	Before exercise	Exercise stopped	½ hr After exercise
Heart-rate (beats/min)	48 ± 2	159 ± 2	68 ± 5
R.Q.	0.87	0.66	0.66
Body Wt. (kg)	68.5	66.1	–

TABLE II

The calculated results for 20 race-walkers at intervals during the routine

Sample period	$\dot{V}_E$	O_2 uptake	R.Q.	O_2 energy value	energy cost	
	L/min	L/min		kJ/L	kJ/min	kJ/min.m²
BEFORE EXERCISE						
resting	7.8 ± 2.4	0.35 ± .16	0.87 ± .13	20.5 ± .1	7.1	3.8 ± 1.1
DURING EXERCISE						
end of ½ hr	52.0 ± 8	2.23 ± .2	0.92 ± .14	20.7 ± .1	46.2	24.7 ± 4.7
end of 1 hr	58.0 ± 17	2.43 ± .9	0.86 ± .19	20.4 ± .2	49.7	26.6 ± 16.6
end of 1½ hr	52.2 ± 9	2.44 ± .4	0.82 ± .18	20.2 ± .3	49.2	26.4 ± 5.2
end of 2 hr	52.6 ± 6	2.52 ± .4	0.77 ± .17	19.9 ± .3	50.3	26.9 ± 5.0
end of 2½ hr	53.4 ± 6	2.65 ± .6	0.72 ± .17	19.7 ± .2	52.1	27.9 ± 5.0
end of 3 hr	56.5 ± 7	2.86 ± .5	0.66 ± .17	19.4 ± .1	55.4	29.7 ± 6.0
Average energy cost					50.5 ± 3.1	27.0 ± 1.7
30 min AFTER EXERCISE						
resting	9.5 ± 3	0.38 ± .2	0.66 ± .18	19.4 ± .2	7.3	3.9 ± 1.2

athletes gives 1.6 x 68.5 = 109 kJ/min. Thus it is most probable that the energy cost of the exercise was met entirely from aerobic metabolic mechanisms and the gradual progressive rise in energy level during the routine indicates an elevation in aerobic activity. This has been proposed by Costill (1970) who studied marathon runners and by Margaria who studied middle distance runners and it would explain our results for race-walkers.

The progressive and marked decrease of R.Q. during the exercise routine indicates rapid depletion of liver glycogen stores and consequent shift to fat as the major energy source. Åstrand and Rodahl (1978) discuss this at length and suggest that fat may be the greatest fuel source for muscular work in long duration submaximal work conditions below the level of anaerobic involvement. Our R.Q. values confirm this view. Additionally, while the heart-rate values indicate that much of recovery may have been completed by 30 min the R.Q. values do not support this assumption; they indicate that while the R.Q. is depressed, recovery of the athletes is incomplete. Unfortunately, it was impossible to collect further R.Q. values on our group of race-walkers and follow their complete recovery. But, we were able to study one subject in detail and found that he took 27 hr to recover to his pre-exercise value. This obviously requires further work and extension of the original routine to study the full recovery period. It will also require an unusually cooperative group of athletes willing to participate in an extended experiment during the final period of training. However, we feel there is sufficient information even in this study to suggest that R.Q. should be used as an index of recovery after exposure to long durations of activity in this type of sport.

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