LaTULIPPE – A CASE STUDY OF A ONE HUNDRED AND SIXTY KILOMETRE RUNNER

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ABSTRACT

A 55 year old runner covered 160 km within a 20 hour period. His speed averaged 8.16 km/h, at an estimated 59.1% of maximum oxygen intake. After the first four hours of running, one of five fluids was taken in rotation every twelve minutes. Volumes ingested were greatest for water (740 ml/h) and least for an ice-cream/syrup mixture (320 ml/h). The heart rate for the final four hours (125/min) was not increased relative to oxygen consumption for this portion of the run. Constancy of heart rate, continued urine production and formal fluid balance calculations all indicate that hydration was well maintained over the run. Caloric intake averaged 480 kcal/h (2.01 MJ/h), being greatest for the ice-cream/syrup mixture; the energy deficit (56 kcal/h, 235 kJ/h) was small during that part of the run in which food was provided.

INTRODUCTION

A previous study of nutritional requirements for a 47 year old man who intended to run across Canada (Shephard et al., 1977) suggested that performance would be limited by the ability to ingest the necessary calories while running. The Trans-Canadian competitor had planned to stop for rest every 48 kilometres. We were thus interested to obtain data on an elderly athlete who ran almost non-stop for 160 km.

EXPERIMENTAL FINDINGS AND DISCUSSION

The runner

The runner, a 55 year old man named LaTulippe, had two years previously established an unofficial world record by covering 480 km in 77 hours. Subsequently, he had maintained his physical condition by running 80-160 km/week.

Although taller than some of his peers (174.5 cm), he had many of the physical characteristics of the ultra-long distance runner, including a light body weight (61.3 kg, some 3 kg less than the actuarial "ideal"), a low percentage of body fat (average of biceps, triceps, subscapular and supra-iliac skinfold thicknesses, 7.1 mm, equivalent to 12.7% body fat; Weiner & Lourie, 1969; Durnin & Rahaman, 1967), and a modest lean body mass (53.5 kg, 307 g/cm standing height). His handgrip force (45 kg, 44 kN) was not outstanding, but lung volumes were somewhat greater than age-related normal figures (vital capacity 4.63 l. BTPS, 106.2%; one second forced expiratory volume 3.64 l. BTPS, 107.1%).

The stroke volume during bicycle ergometry (CO_2 rebreathing method of Jones, 1975) was essentially normal (110 ml. at 100 Watts, 107 ml. at 150 Watts), as were the corresponding values for cardiac output (13.3 and 15.5 l./min) and arterio-venous oxygen difference (90 and 122 ml./l). However, the maximum oxygen intake was 53% above the Toronto average for a sedentary individual of comparable age (Shephard, 1977). The maximum workload attained on the bicycle ergometer was 183 Watts, at a heart rate of 161/min; the corresponding oxygen consumption was 2.77 l./min, 43.6 ml./kg.min STPD, with a respiratory gas exchange ratio of 1.15. During uphill treadmill running (Shephard et al., 1968), the maximum oxygen intake was 14.8% larger (3.18 l./min, 50.5 ml./kg.min).

Good use was made of the available oxygen transport; earlier measurements by Kofranyi-Michaelis respirometer had shown that his running efficiency was some 5.9% greater than average for young adults (Shephard, 1968).

The run

The run took place on a quarter mile cinder track. The first four hours of activity were totally uninterrupted. Thereafter, the subject slowed to a walk every 12 min to ingest one of five fluids (Table I) taken in rotation. Brief (2.5 min) halts were made for physiological monitoring after 4, 7, 9, 11, 15 and 17 hours of running. Ambient temperatures ranged from 12 to 20°C, with wind speeds of 15-17 km/h. More than 50% of the running took place at night.

TABLE I

Fluid and water intake over 160 km run. Items were administered in rotation at 12 minute intervals, commencing in the fifth hour of running, and continuing to the twentieth hour

Preparation	Weight (g)	Percentage moisture	Caloric yield Kcal/g	Total Energy yield Kcal	MJ	Total water ml
Tea, syrup, sugar	2002	81.9	0.76	1522	6.38	1638
Beef broth	1660	96.2	0.08	133	0.56	1597
Mushroom soup with milk	2368	83.3	1.06	2510	10.52	1974
Ice-cream with syrup and milk	1972	65.6	1.79	3530	14.79	1292
Water	2973					
Total intake	10975			7695	32.24	9474

Total energy cost for 20 hr (assuming 4.85 Kcal/l. of oxygen) 10700 Kcal (45 MJ)

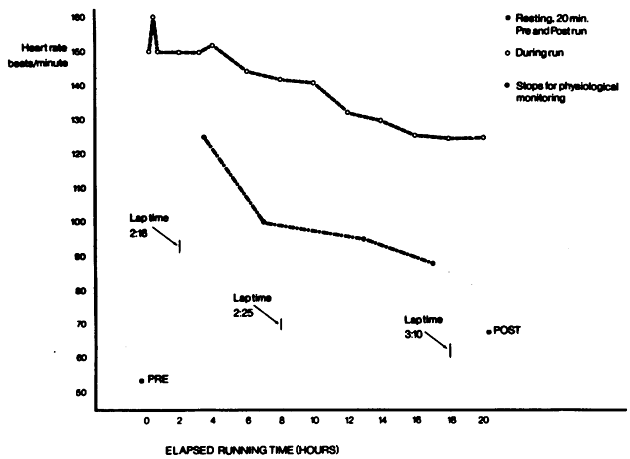
Performance during the run

The total running time for the 160 km was 1177 min, corresponding to an average speed of 8.16 km/h. The oxygen cost in an average subject would have amounted to 32 ml./kg.min, but because of the increased efficiency of running, LaTulippe would have used no more than 30 ml/kg.min, or 59.1% of his maximum oxygen intake. Industrial physiologists have recommended that to avoid fatigue, energy expenditures should not exceed 40% of aerobic power, averaged over an eight hour day (Åstrand, 1960, 1967; Bonjer, 1968; Shephard, 1977). In marathon racing, 75% of aerobic power may be sustained for several hours of activity (Costill, 1970; Kavanagh & Shephard, 1977). Nevertheless, it is an exceptional achievement for a 55 year old man to use 59% of his maximum oxygen intake continuously for 20 hours.

It is further remarkable that despite the intensity of effort, the heart rate did not show a progressive increase over the run (Fig. 1). There was some slowing of track speed over the 20 hours, but the heart rate during the final 4 hours of the event (125 beats/min) would have been anticipated as an early response to the oxygen usage of this period; (56% of maximum oxygen intake). The ability to sustain a slow heart rate is partly an expression of training for ultra-long distance running, although other favourable factors included cool weather and the maintenance of plasma volume through a large fluid intake.

The initial systemic blood pressure (right arm, one minute of seated rest) was 140/75 mm Hg (18.7/10.0 kPa). This was fairly well sustained over the run, corresponding figures being 115/75 (15.3/10.0) at 4 and 13 hours, and 125/70 (16.7/9.3) thirty minutes after completion of the run.

Fig. 1. Heart rate during 160 km run, as measured by telemetry.



The pre-race electrocardiogram showed negative P waves in leads II and III, suggesting either an upper nodal or a coronary sinus rhythm. This dislocation of the pacemaker disappeared over the course of the run, and had not reappeared by the twentieth minute of recovery.

Core temperatures were monitored by an intra-gastric radio pill (D.C.I.E.M., 1974). The initial reading was 36.7°C, and at no point did the recorded value exceed 37.4°C.

Fluid balance

Nothing was ingested over the first four hours of the run. Thereafter, five fluids were taken in rotation (Table I). Ingestion averaged 592 ml./h. The largest volumes were drunk at the stops where water was provided, and the smallest when the mixtures contained ice-cream, syrup and milk. The fluid intake was substantially better than the 250 ml./h accomplished by our cross-Canada runner (Shephard et al., 1977) and indeed compares quite favourably with the 800 ml./h achieved by Costill (1972) when young subjects drank 4-5% glucose solutions for a total of less than two hours.

The body weight registered a decline of 3.9 kg during the first 4 hours of the run, with a steady recovery thereafter, the final figure being 1.85 kg greater than the initial reading. Calculations of the corresponding water balance (Table II) are at first glance a little puzzling, since a positive balance of some 3.8 litres apparently was accumulated over the twenty hour run. Continued urine flow (Table IV) shows that an adequate fluid intake was achieved, but the plasma composition (Table III) does not suggest that there was extensive haemodilution. One likely source of error in the fluid balance calculations is an accumulation of sweat in the shorts of the runner; this could easily account for 250 ml. of fluid. It is also possible that at least a litre of fluid was ingested but not absorbed over the course of the event; four bowel movements towards the end of the run support the idea that some gastric distension had developed. Lastly, there was undoubtedly fluid accumulation in the active tissues; some authors have suggested that muscles can gain 20% of their initial volume through an accumulation of tissue fluid during sustained activity.

Energy balance

The energy intake accomplished with the present selection of fluids (Table I) averaged 480 kcal/h, 2.01 MJ/h; this was better than could be achieved with any of the food mixtures tested on the cross-Canada runner (Shephard et al., 1977), and also compares favourably with the 152 kcal, 635 kJ, yielded by 800 ml. of 5% glucose (Costill, 1972). Caloric intake was greatest with the ice-cream mixture, and was least when the beef broth was provided.

TABLE II

Fluid and energy balance for the 160 km run*

Weight change:		
Food and water ingested	10975 g	gain
Combustion of mixture of 800 g fat and 929 g carbohydrate to 1307 ml water and ~10,700 Kcal (45 MJ)	422 g	loss
Urine 1197 ml, sg 1.030	1233 g	loss
Respiratory water vapour	2110 g	loss
Faeces (4 bowel movements)	500 g	loss
Sweat production	4860 g†	loss
Net weight gain	1850 g	
Water balance:		
Fluid intake	9474 ml.	
Metabolic water production	~1300	
Glycogen release	~1600	
Total water income	12374	
Urine output	1197 ml.	
Respiratory water loss	2110	
Faecal water loss .	400	
Sweat loss	4860	
Total water expenditure	8567	
Positive water balance	3807 ml.	

*For details of calculations, see D.C.I.E.M. report. In press.

†The low rate of sweat production (243 ml./h) reflects the cool environmental conditions, with radiant heat loss during the night hours.

TABLE III

Blood Chemistry Results: SMA-12

TEST	RESULTS 2 Hours Before	During (7 hr)	After (30 min)	After (24 hr)
Calcium (mg/dl)	10.3	10.8 H	9.3	9.0
Inorganic Phosphorus (mg/dl)	3.2	4.2	3.6	2.2 L
Glucose (mg/dl)	105.0	139.0 H	109.0	102.0
Urea Nitrogen (mg/dl)	27.0 H	37.0 H	35.0 H	23.0 H
Uric Acid (mg/dl)	4.7	6.3	5.4	5.0
Cholesterol (mg/dl)	265.0	285.0	210.0	207.0
Total Proteins (g/dl)	7.4	7.5	6.2	6.5
Albumin (g/dl)	4.74	4.82	4.01	4.14
Total Bilirubin (mg/dl)	0.6	0.8	0.9	1.1 H
Alkaline Phosphatase (U/l)	60.0	85.0	82.0	69.0
LDH (U/L)	194.0	293.0 H	363.0 H	293.0 H
SGOT (U/L)	51.0 H	83.0 H	370.0 H*	200.0 H

dl: 100 ml
H: Higher than normal data for fasting adult
L: Lower than normal data for fasting adult
*: Rechecked in dilution
NOTE: Only last column is fasting

TABLE IV
Routine Urinalysis

TIME (ml)	Volume (ml)	SG	pH	Protein	Ketones
23 May					
0630	248	1038	5.0	Neg	Neg
1200	170	1032	5.5	Neg	Neg
1530	172	1030	5.0	Neg	Neg
1730	176	1027	5.0	Neg	Neg
2000	120	1033	5.5	Neg	Neg
24 May	—	—	—	—	—
0630	302	1031	5.0	Trace	Neg
1100	180	1032	5.5	Neg	Neg
1300	95	1028	5.0	Neg	Neg
1745	157	1029	5.0	Tr	Neg
1920	75	1032	5.5	Tr	Neg
2100	90	1030	6.0	Tr	Neg
2300	115	1031	5.0	Tr	Neg
2400	0*	—	—	—	
25 May					
0100	135	1030	5.0	Tr	Neg
0400	225*	—	—	—	Neg
0525	135	1027	5.5	Tr	Neg
0630	100*	—	—	—	
0725	90	1024	5.0	Tr	Neg
0810	75*	—	—	—	
1130	150	1024	5.0	Tr	Small
1700	220	1030	5.5	Tr	Mod-heavy
**					
26 May					
0815	140	1034	5.0	Tr	Small

SG: Specific Gravity
*: Interpolated urine loss associated with bowel movement
**: Late evening sample not collected
NOTE: Double lines indicate beginning and end of run

Over the sixteen hours that food was being ingested, the apparent energy deficit was no more than 56 kcal/h, 232 kJ/h. The actual deficit would have been somewhat larger if not all of the fluid had been absorbed. Nevertheless, there are several pointers to a well-sustained energy balance, including continued high blood glucose readings (Table III), unchanged skin and skinfold thicknesses, and the absence of ketosis during the run (Table IV).

Blood chemistry and urinalysis

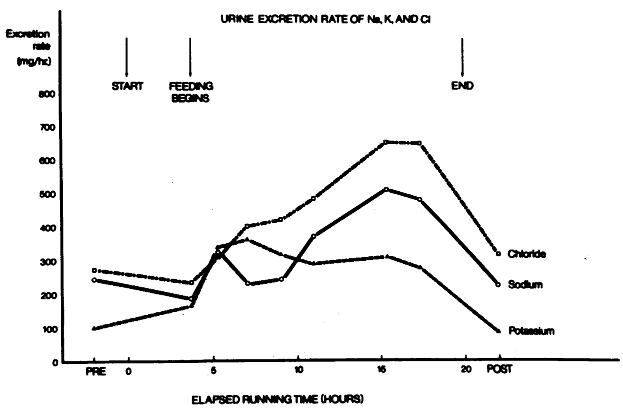
The SMA-12 results are summarized in Table III. Urea nitrogen showed a small increase during and immediately after the run, indicating some protein catabolism, possibly coupled with a reduction in renal clearance of urea. However, the increase of plasma urea was smaller than we have observed in marathon events (Shephard et al., 1977). This may reflect not only the good energy balance, but also the fact that the 160 km run was conducted at a smaller fraction of maximum oxygen intake, with a corresponding reduction in the need for anaerobic work. The rise of cholesterol during the event, with a fall immediately afterwards was confirmed by duplicate analyses in a second laboratory. It suggests that there was some mobilization of depot fat during the run. As in other distance events, very large increases of serum SGOT and LDH were registered. Nevertheless, there were no overt symptoms or signs of muscle injury during or following the event.

The subject urinated throughout the race (Table IV). The maximum specimen volume was 157 ml., with a urine flow of 32 ml./h over the first four hours, and a gradual increase thereafter to about 95 ml./h. Urinary sodium and chloride excretion decreased during the first four hours of activity, but once fluid intake commenced their elimination increased to more than twice the resting rate (Fig. 2). Potassium excretion was greater than the previous resting level throughout the run. Ketone bodies were found in fairly heavy concentrations immediately following the run. No more than a trace of proteinuria was seen during and following exercise.

Choice of fluid for ultra-long distance running

The present data show that under cool conditions it is possible to ensure a substantial energy intake while meeting the fluid needs of the body. In a hotter environment it would be necessary to decide whether energy or water needs limited performance, and to choose the fluid accordingly. If the problem is dehydration, the best antidote seems pure water (Shephard et al., 1977).

Fig. 2. Urinary excretion of potassium, sodium and chloride over 160 km run



REFERENCES

Åstrand, I. 1960, Aerobic work capacity in men and women with special reference to age. *Acta physiol.Scand.,* **49**: Suppl. 169, 1-92.

Åstrand, I. 1967, Degree of strain during building work as related to individual aerobic work capacity. *Ergonomics* **10**: 293-303.

Bonjer, F. H. 1968, Relationship between working time, physical working capacity and allowable calorie expenditure. In: Rohmert, W. (Ed.). Muskelarbeit und Muskeltraining. Gentner Verlag; Stuttgart.

Costill, D. L. 1970, Metabolic responses during distance running. *J.appl.Physiol.* **28**: 251-255.

Costill, D. L. 1972, Fluid replacement during and following exercise. In: Fitness and Exercise. Ed. Alexander, J. F., Serfass, R. C. and Tipton, C. Athletic Institute: Chicago.

D.C.I.E.M., 1974, March, A description of the components of the disposable DCIEM radio pill, used to monitor body core temperature. *Quarterly Newsletter,* **3**, Number 1.

Durnin, J. V. G. A. and Rahaman, M. M. 1967, The assessment of the amount of fat in the human body from measurement of skinfold thickness. *Brit.J.Nutr.* **21**: 681-689.

Jones, N. L., Campbell, E. J. M., Edwards, R. H. T., and Robertson, D. G. 1975, Clinical exercise testing. W. B. Saunders: Philadelphia.

Kavanagh, T. and Shephard, R. J. 1977, On the choice of fluid for the hydration of the middle-aged marathon runner. *Brit.J.Sports Med..,* **11**.

Shephard, R. J. 1968, A nomogram to calculate the oxygen cost of running at slow speeds. *J.Sports Med.Phys.Fitness,* **9**: 10-16.

Shephard, R. J., Allen, C., Benade, A. J. S., Davies, C. T. M., di Prampero, P. E., Hedman, R., Merriman, J. E., Myhre, K., and Simmons, R. 1968, The maximum oxygen intake — an international reference standard of cardio-respiratory fitness. *Bull.W.H.O.,* **38**: 757-764.

Shephard, R. J. 1977, Endurance Fitness. Second Edition. University of Toronto Press: Toronto.

Shephard, R. J., and Kavanagh, T. 1975, Biochemical changes with marathon running. Observations on post-coronary patients. In: Metabolic adaptation to prolonged physical exercise. Ed. Howald, H. and Poortmans, J. R., Birkhauser Verlag, Basel.

Shephard, R. J., Kavanagh, T., Conway, S., Thomson, M., and Anderson, G. H., 1977, Nutritional demands of sub-maximum work: marathon and Trans-Canadian events. Proceedings of International Symposium on Athletic Nutrition, Warsaw, 1975: In press.

Weiner, J. S. and Lourie, J. A. 1969, Human Biology: A guide to field methods. Blackwell, Oxford.