CASE STUDY

BEIJING TO HONG KONG SUPER-MARATHON — SPORTS MEDICINE RESEARCH

K. M. CHAN, MB, BS, FRCS(E), FRCS(G), MCh(ORTH), FRCSED(ORTH), P. DIAMOND, MD, C. K. LAW, SRP,
S. HSU, MB, BS, FRCS(E), P. C. LEUNG, MB, BS, MS, FRCS(E), FRACS, S. Y. SO, MB, BS, MRCP,
R. WANG, MD, MRCP, FACC and W. Y. SHEN, MBBS

(This study is a joint project of the Department of Orthopaedic & Traumatic Surgery, the Chinese University of Hong Kong and the Division of Cardiopulmonary Medicine, Department of Medicine, University of Hong Kong)

INTRODUCTION

The challenge to nature is a human instinct. The test of his own physique and will-power in endurance sports is yet another challenge. All over the world, people are trying to reach the ultimate of physical capabilities in walking, running, cycling, swimming, canoeing, hang-gliding . . .

The Super-Marathon Run from Beijing to Hong Kong covers about 3,000 kilometres in 55 days — an equivalent of approximately 70 consecutive Marathons. The run was performed by one man. There have been records of even longer distances covered by runners, but as yet no medical study has been conducted to unveil the hitherto mysteries of the body's physiological endurance.

The main objective of this study is to explore the physiological changes in the cardio-pulmonary and musculo-skeletal systems, the body's demand in fluid and nutrition and the emotional and psychological adjustment.

THE RUN

This epic Beijing to Hong Kong Super-Marathon run covered six provinces in China (Hobei, Shandong, Honan, Hubei, Hunan, Guangdong) with seven stops in major cities (Baoding, Dezhou, Kaifeng, Wuhan, Changsha, Shaoguan, Guangzhou) as indicated on the route map (Fig. 1). This is a relatively less well-known route in China as most of the terrains are hitherto not yet opened to tourism. A logistic team had explored the entire route together with a special team from the China Sports Association to work out the details of the trip. The entire route was covered by the runner himself. Throughout the trip he was regularly accompanied by a body-guard from China, half of the way by a doctor, P. Diamond and the other half by a physiotherapist C. K. Law and they were responsible for monitoring the various tests on him. Some local Chinese runners joined in certain section of the run as a gesture of moral support.

The road condition of the route varied considerably:— near to towns and cities, there were tarmac roads available and usually there was no steep camber falling away towards the road verges (Fig. 2), the majority of the route was rough gravel and beaten earth (Figs. 3 and 4 on front cover).

The run was accomplished between mid-October to early December 1983. Starting from Beijing, the average temperature was -5°C to 5°C and gradually, warming up to 5°C to 10°C in the great plain of China. Across the mountainous region of Hubei and Hunan, the temperature dropped somewhat at high altitudes to 0°C to 5°C . The final leg of the journey across the Guangdong province was warmer 10° to 15°C . The relative humidity ranged between 55% to 85% and

winds were occasionally strong in the hilly terrains. A great part of the running was scheduled in the morning and early afternoon in order to maximise the benefit of daylight.

METHOD

The subject was a 43 year old British amateur athlete height 179 cm and weight 64.9 kg. His regular employment is a company director in Hong Kong. He also plays tennis and golf.

The study was conducted in 3 phases:—

Phase 1 This was the pre-run test including:

1. A full cardiovascular check-up and the treadmill test.
2. A full complement of lung function tests and chest X-ray.
3. A complete profile of the haematological and urine biochemistry.
4. A clinical screening assessment of the musculo-skeletal function.

Address for correspondence:

Dr. K. M. Chan
Dept. of Orthopaedic & Traumatic Surgery
The Chinese University of Hong Kong
Shatin, N.T.,
Hong Kong

Phase 2 During the run, a daily monitor of the body's vital functions was recorded including pulse, blood pressure, temperature, vital capacity of the lung and routine urine test. The road condition, weather, running and resting pattern and a complete record of fluid and diet was also made.

Phase 3 The pre-run tests were repeated immediately after the run and then one month later to observe changes after an adequate period of rest.

A full cardiovascular evaluation including history, physical examination, electrocardiogram, 2 dimensional echocardiogram (Varian 300 phase array system) and treadmill exercise test (Marquette Case exercise system) using Bruce protocol was performed before and one day after the super-marathon run. The echo-dimensions (left ventricular end-diastolic diameter and end-systolic diameters) were measured from the parasternal long axis view. The exercise test was terminated when age predicted maximal heart rate was reached. During the run, the systolic blood pressure by palpation and pulse rate were taken daily before and after running.

Static and dynamic lung volumes, carbon monoxide gas transfer (single breath) were measured before and one day after the whole race using a rolling-seal spirometer (Gould 5000 IV). Vital capacity was also measured daily before and immediately after the run using a portable turbine spirometer (Super).

RESULTS

The Cardiovascular Status

The runner did not have any cardiac symptoms before, during and after the run. The cardiovascular examination was completely normal before and after the run. Table I summarises the results of the cardiovascular examinations. There was no change in the resting blood pressure, 12 lead electrocardiogram and echocardiographic dimension. There was a slight increase in the resting pulse rate (61 to 71/min) and also the exercise time to age predicted maximal heart rate decreased from 24 to 21 minutes.

TABLE I

Cardiovascular findings before and after the ultra-marathon run.

	Before	After
Resting pulse (/min)	51	71
Resting blood pressure (mmHg)	120/80	120/80
12 lead ECG	Normal	Normal
LVSD (cm)	3.3	3.2
LVDD (cm)	5	4.9
LVPW (cm)	1.1	1.1
Treadmill time (min)	24	21

LVSD – left ventricular end-systolic diameter

LVDD – left ventricular end-diastolic diameter

LVPW – left ventricular posterior wall thickness

From the daily running chart, the pre-run pulse rate varied from 49 to 76 (mean of 62/min), the post run pulse rate 54 to 100 (mean of 72/min), the pre-run systolic pressure 100 to 130 (mean 109 mm Hg) and the post run systolic pressure 98 to 130 (mean 106 mm Hg).

The Pulmonary Status

There was no change in FEV, FVC and PFR before and one day after the whole race. However there was a 10% fall in expiratory flow rate at low lung volumes (FEF_{25-75%}, FEF_{50%}), suggestive of the development of small airway obstruction. This was confirmed by a rise of 12.4% in residual volume. Values for carbon monoxide gas transfer remained unchanged.

Vital capacity, measured daily before and immediately after the run, rose by 5% (mean value). Table II summarises the results of lung function changes.

The Nutritional Status

The dietary profile of this super-marathon run was charted and compared with the recommended format by a nutritionist (Table III). It was recognised that essentially the fluid and caloric demand of this run was compatible with most endurance sports but there was a significant proportion of meat consumption, probably related to the superb hospitality of the local Chinese community throughout the entire run.

The Musculo-Skeletal Status

In this super-marathon run, patello-femoral joint pain set in early during the first week. The pain was tolerable in the beginning and could

TABLE II
Lung function changes.

	Pre-race	Post-race	Change (%)
Dynamic lung volumes			
Forced expiratory volume: 1 sec (L)	4.66	4.63	-0.6
Forced vital capacity (L)	5.70	5.80	+1.7
Forced expiratory volume/ Forced vital capacity (%)	82	80	
Peak flow rate (L/sec)	11.72	11.99	+2.2
Forced expiratory flow 25%-75% (L/sec)	4.50	4.10	-9.7
Forced expiratory flow 50% (L/sec)	5.59	5.08	-10.0
Forced expiratory flow 75% (L/sec)	1.95	1.91	-2.0
Static lung volumes			
Vital capacity (L)	5.83	5.84	+0.2
Residual volume (L)	1.94	2.18	+11.0
Total lung capacity (L)	7.77	8.02	+3.1
Residual volume/Total lung capacity	25	27	
Diffusion			
Carbon monoxide gas transfer (ml/min/mmHg)	37.3	37.8	+1.3
KCO (l/min/mmHg)	4.47	4.58	+2.5

TABLE III
Dietary profile.

Diet	The Super-Marathon (Average)	Recommended Diet
Fluid	17 glasses (5800 ml/d)	10-20 glasses (3500-7000 ml/d)
Calories	5500 cal/d	3000-8000 cal/d
Meat (%)	29%	10-20%
Cereal, vegetables, sugar in drinks (%)	48%	50-55%
Fat (%)	23%	30-35%

be controlled with analgesics and pressure bandaging. The running schedule was not disrupted. In the second week, there was a moderate effusion of the knee leading to quite persistent pain. Anti-inflammatory analgesics and traditional Chinese acupuncture were tried with slight improvement. Fortunately an orthopaedic surgeon was accompanying the team during the early part of the run; an intra-articular injection of steroid was tried with good result. Subsequently a physiotherapist joined in and the management was carefully planned in consultation with the research team in Hong Kong. The time-honoured method "RICE" (rest, ice, compression and elevation) was utilised with some modifications:— the relatively loose knee guard was replaced by coban bandage, ice cube friction with or without analgesic spray to the tender spots together with cold pad were applied; kneading and effleurage of both lower limb muscles was done before and after each segment of the running.

The whole running schedule was revised with particular considerations of the following preventive measures:—

- The resting time of each segment was prolonged.
- Rough surface was avoided as far as possible and the runner was encouraged to run on both sides of the road alternately.
- Adequate stretching and warm-up exercise were strictly enforced. The patello-femoral joint pain was well controlled to the end of the whole run. Foot problem was not worrying in this run because of meticulous attention in footwear and foot care.

DISCUSSION

Endurance training usually produces athlete's heart syndrome with cardiac enlargement, sinus bradycardia and occasionally abnormal auscultatory and electrocardiographic changes (Gott et al, 1968; Lichtman et al, 1973). However, in our subject, no significant cardiovascular changes occur after the super-marathon run. The slight increase in resting heart rate and the decreased exercise time to reach the age predicted heart rate are most probably due to exhaustion. But there is

no development of left ventricular hypertrophy or cardiac enlargement from the electro-cardiographic and echocardiographic examinations. This is most likely due to the well-planned running schedule which does not strain the heart excessively. Although the distance covered is tremendous, this is well spread over 55 days. Thus, there is adequate rest in between each running session as evidenced by the steady blood pressure and pulse reading daily after the run. This study confirms the clinical impression that any exhausting exercise of which a young adult is capable does not impose any ill effects on the heart.

This super-marathon run is a test of human endurance. One would expect the development of fatigue of respiratory muscles after the run, as reflected by a fall in vital capacity (Loke et al, 1982). However the vital capacity in this case remained unchanged. It could be argued that the post-race vital capacity did not reflect the true state of our runner, as it was taken after a day's rest. However the mean vital capacity actually rose by 5% after the daily run, with no indication of gross muscle fatigue. It is possible that the measurement of vital capacity may not be sensitive enough, as Loke and his associates had demonstrated muscle fatigue shown by a fall in maximal inspiratory and expiratory pressures and maximal voluntary ventilation, but with no change in vital capacity, after marathon running (Loke et al, 1982).

The fall in expiratory flow at low lung volumes together with a rise in residual volume is suggestive of the development of small airway obstruction after the race. Similar findings had been reported after competitive marathon running (Maron et al, 1979), although the mechanism is unknown. It could also be unrelated to the marathon, as our runner had developed a respiratory tract infection one month before the last lung function testing, and mild airflow obstruction had been shown to persist for some weeks after such an infection (Picken et al, 1972).

To enhance the efficiency of food utilisation during the different phases of metabolism of exercise, the following recommendations have been advocated to endurance athletes (Mirkin et al).

- (a) Consume only as many calories as are expended.
- (b) Increase complex carbohydrate consumption to about 48% total calories (in the form of cereals, grains and the natural sugars found in fruits). Reduce refined sugar consumption to 30% of calories.
- (c) Reduce overall fat consumption to 30% of calories, and partially substitute polyunsaturated fat for saturated fat.
- (d) Reduce cholesterol consumption to about 300 mg/d by reducing the intake of butter, fat and eggs.
- (e) Decrease consumption of red meat and increase consumption of poultry and fish.
- (f) Reduce salt consumption to 5 mg/d.

To a great extent, the above nutritional advice was well-observed in this super-marathon run. However it should be emphasised that endurance athletes should cultivate such a habit at the very beginning of the training programme.

It is well known that over-use problems, in long-distance running, usually manifest in the form of foot problems, shin splint, exertional compartmental syndrome, tendinitis/tendon rupture, stress fracture, knee pains and low back pain (Mack, 1982). In this super-marathon run, the patellofemoral pain is probably related to a host of factors:— prolonged running on unequally inclined and occasionally rough road surfaces, a much extended distance covered daily than the previous training schedule, inadequate stretching and warm-up exercises. Persistent knee pain is a real threat to any long-distance runner because apart from complete rest of the knees, there is no ideal temporising measure. Perhaps it is not so well appreciated in the early planning that a seemingly trivial injury

of the lower limb may jeopardise the success of the entire run. Early detection of the source of the problem is mandatory because progression of damage can be avoided.

CONCLUSION

This research study illustrates the importance of team approach in sports medicine. Careful planning on the total care of the athlete should start before, during and after any endurance sports such that the maximum capability of the athlete can be realised in safety and with confidence. Prevention of injuries is always the first priority. With the growing enthusiasm in sports participation in the recreational and competitive fields, we hope that this study will stimulate interest on exercise science and sports medicine among the related professionals. Together we strive to achieve the ultimate goal of "sports for all".

ACKNOWLEDGEMENT

The authors would like to thank Mr. D. Griffiths, the super-marathon runner, and the team in co-operating with this research project.

References

- Gott, P. H., Roselle, H. A. and Crampton, R. S., 1968 "Five-year cardiac evaluation of a champion athlete". *Arch.Intern.Med.* 122: 340-4.
- Lichtman, J., O'Rourke, R. A., Klein, A. and Karliner, T. S., 1973 "Electrocardiogram of the athlete: alternations simulating those of organic heart disease". *Arch.Intern.Med.* 132: 763-70.
- Loke, J., Mahler, D. A. and Virgutto, J. A., 1982 "Respiratory muscle fatigue after marathon running". *J.Appl.Physiol.* 52 (4): 821-824.
- Mack, R. P. (Ed.), 1982. *American Academy of Orthopaedic Surgeons Symposium on the Foot and Leg in Running Sports*. Chapters 13, 15 and 17. C. V. Mosby Company, St. Louis.
- Maron, M. B., Hamiton, L. H. and Maksud, M. G., 1979 "Alterations in pulmonary function consequent to competitive marathon running". *Med.Sci.Sports* 11: 244-249.
- Mirkin, G. and Hoffman, M. *The Sports Medicine Book*. Chapter 6, p. 57. Little, Brown & Company (Canada) Limited.
- Picken, J. J., Niewoehner, D. E. and Chester, E. H., 1972 "Prolonged effects of viral infection of the upper respiratory tract upon small airways". *Amer.J.Med.* 52: 738-746.

Mr. David Griffiths, a 43 year old British amateur athlete, undertook this run to try to raise money to enable disabled Chinese and Hong Kong athletes to participate in the 1984 Seventh World Wheelchair Games at Stoke Mandeville, Buckinghamshire, UK and in the 1984 International Games for the Disabled in New York.

The logistic medical support was organised by the Department of Orthopaedic and Traumatic Surgery, the Chinese University of Hong Kong, and provided by Dr. Peter Diamond, MD — one of the authors of this report, for the first half of the run and later by Mr. C. K. Law, SRP — another author, both of support team travelled in a truck equipped as a caravan with cooking, bathing and sleeping facilities — "the big yellow hotel that moves". Usually, however, rural accommodation or small town hotels were used.

By Day 30, the Northern Chinese Plain was left behind and the route involved hills of 2,000 feet (approx. 650 metres), and cold running conditions.

The run ended at the Wan Chai Sports Ground in Hong Kong after 55 days. Sponsorship and donations ranging from 35 Cents US upwards eventually realised £165,000 for the handicapped athletes of China and Hong Kong.

A fascinating account of this run appeared in the Reader's Digest, July 1985 written by the runner himself and includes his many adventures; — being on the fringe of an earthquake of appreciable severity and assisting with the delivery of a baby, amongst others. Apart from the money raised, the run was greeted with enthusiasm by the people along the route, especially the disabled and must have fostered international understanding through sport.

Editor