Acute Effects of Marathon Running on Postmarathon Maximal Oxygen Uptake

Kan-ichi MIMURA¹⁾, Tamio NISHIMURA¹⁾, Kyosuke YAGITA²⁾,
Kiyoji TANAKA³⁾ and Kazuya MAEDA³⁾

1) *Department of Physical Education, Osaka Kyoiku University, Johnan, Ikeda, Osaka 563, Japan*

2) *Department of Physical Education, Osaka University of Economics, Ohsumi, Higashi-Yodogawa, Osaka 553, Japan*

3) *Department of Health Science and Physical Education, Osaka City University, Sugimoto, Sumiyoshi, Osaka 558, Japan*

INTRODUCTION

Marathons are getting popular not only among physically trained individuals but also among less conditioned men and women. It is well-known that many of those entering popular marathon races have relatively higher levels of maximal aerobic power and anaerobic threshold (Costill et al., 1973; Pollock, 1977; Tanaka and Matsuura, 1984; Tanaka et al., 1984). Most participants in marathon races, however, suffer from an acute impairment of physical work capacity and delayed muscle soreness accompanied by diminished performance capacity (Sherman et al., 1984). Little data are available on the effects of marathon running on postmarathon maximal aerobic power. The purpose of this study was to investigate acute effects of marathon running on subsequently measured 3-day postmarathon maximal oxygen uptake.

METHODS

Three conditioned male distance runners accustomed to motor-driven treadmill running exercise volunteered as subjects for this study. Informed consent was obtained from each subject after being fully informed about the purpose, procedure and possible risks involved.

The subjects took part in a local marathon race held on March 8, 1986 in Sasayama, Hyogo, Japan. The race was held on a relatively flat course under ideal conditions (mean temperature=14.5°C and mean relative humidity=31.0%).

Testing was accomplished four times on different days. In the premarathon test which was conducted 5-7 days prior to the marathon competition, a progressive incremental treadmill protocol was used for determination of the individual's maximal oxygen uptake. Postmarathon tests were done 1, 2, and 3 days after the marathon competition. Each subject wore the same shoes and similar clothing for the laboratory testing as he had worn during the marathon race. Maximal oxygen uptake was defined as the highest mean value of the sum of two successive 30s oxygen uptake values recorded during the incremental work test.

Metabolic measurements of expiratory gases were determined by standard techniques of open-circuit spirometry, using Mijnhardt Oxycon System (Tanaka et al., 1986). Gas analyzers for O₂ and CO₂ involved in the system were calibrated before and after each test with standard gases of known concentrations.

RESULTS

Mean ($\pm$ SD) age, stature, body weight, maximal oxygen uptake, and maximal heart rate for the present subjects were 33.0 ± 3.5 yr, 169.1 ± 5.2 cm, 60.5 ± 1.3 kg, 72.0 ± 3.9 ml/kg/min, and 187.3 ± 1.5 b/min, respectively (Table 1). All the subjects performed personal records in the marathon with a mean time of $3\text{h } 17\text{min} \pm 22\text{min}$.

Analysis of the data indicated that there were

remarkable decrements in maximal oxygen uptake after the marathon race (Fig. 1 and Table 2). Maximal oxygen uptake in the postmarathon tests corresponded to 85.3–88.8% of the premarathon maximal oxygen for subject H.O., and 76.0–80.7% of the premarathon maximal oxygen uptake for subject K.K., and 85.3–89.7% of the premarathon maximal oxygen uptake for subject T.K. The magnitude of these decrements in postmarathon maximal oxygen uptake was largest on day 1 postmarathon for all

runners and smallest on day 3 postmarathon for two of the three runners.

DISCUSSION

Well-trained distance runners are generally characterized by a high level of maximal aerobic power and anaerobic threshold (Costill et al., 1973; Pollock, 1977; Tanaka and Matsuura, 1984; Tanaka et al., 1984). Our subjects showed the characteristi-

Table 1. Premarathon profiles of runners.

	subject			Mean±S.D.
	H.O.	K.K.	T.K.	
Age, yr	29	36	34	33.0±3.5
Stature, cm	170.5	163.2	173.6	169.1±5.2
Weight, kg	59.5	60.0	62.0	60.5±1.3
HRmax, b/min	189	187	186	187.3±1.5
$\dot{V}O_2$ max, ml/kg/min	67.8	72.4	75.7	72.0±3.9

HRmax; maximal heart rate, $\dot{V}O_2$ max; maximal oxygen uptake

Table 2. Postmarathon $\dot{V}O_2$ max of runners.

	subject			Mean±S.D.
	H.O.	K.K.	T.K.	
Day 1	57.5 (85.3)	55.0 (76.0)	64.6 (85.3)	59.0±4.9 (82.2±5.3)
Day 2	59.4 (87.6)	57.5 (79.4)	67.9 (89.7)	61.6±5.4 (85.6±5.3)
Day 3	60.2 (88.8)	58.4 (80.7)	66.5 (87.8)	61.7±4.2 (85.8±4.3)

Values are expressed as ml/kg/min with relative figures (%) of the premarathon $\dot{V}O_2$ max in parentheses.

Fig. 1. Comparison of $\dot{V}O_2$ max values determined before a marathon and 1, 2, and 3 days postmarathon.

cally high maximal oxygen uptake. Although the mean maximal aerobic power for the present subjects was 72.0 ± 3.9 ml/kg/min, two of the runners were not capable of running the marathon distance in less than 3 hours. The present runners were therefore considered as not being elite competitors, but represented a cross-section of the individuals participating in a major city marathon race.

On day 1 postmarathon, all subjects' maximal oxygen uptake was less than 86% ($82.2 \pm 5.3\%$) of their premarathon maximal oxygen uptake. On day 2 postmarathon, their maximal oxygen uptake was still depressed ($85.6 \pm 5.3\%$) at 90% of their premarathon maximal oxygen uptake. More interestingly, mean 3-day postmarathon maximal oxygen uptake for the subjects corresponded to only $85.8 \pm 4.3\%$ of their premarathon maximal oxygen uptake. It is therefore apparent that postmarathon maximal oxygen uptake in average competitors is greatly impaired when compared with premarathon maximal oxygen uptake levels.

An improving tendency of postmarathon maximal oxygen uptake from day 1 to day 3 may be due partly to a reduction in muscle soreness. In fact, all the subjects reported that soreness of their quadriceps was reduced gradually during this period. Sherman et al. (1984) found that both rest-and exercise-recovery groups of marathon participants regained some of their loss of muscle function after the marathon through day 3 postmarathon. Furthermore, it is of great interest that, although there was essentially no muscle soreness for 5-7 postmarathon days, leg extensor strength as measured by maximal peak torque remained depressed (Sherman et al., 1984). Our observations in terms of maximal aerobic power, together with those results, might indicate a persistence of muscle dysfunction.

Sherman et al. (1983) reported that muscle glycogen was depleted predominantly in both the slow-twitch and fast-twitch (oxidative glycolytic) fibers by marathon running concomitant with impaired leg extensor strength. Interestingly however, muscle

glycogen returned to normal level days 1-7 postmarathon in spite of the presence of lowered leg extensor strength throughout the postmarathon week.

Thus reduced maximal oxygen uptake levels days 1-3 postmarathon observed in the present study might not be accounted for by muscle glycogen levels. Other factors (e.g. reduced muscle strength and/or a persistence of muscle soreness) rather than muscle glycogen levels seem to limit the postmarathon cardiorespiratory capacity.

In conclusion, we suggest that maximal oxygen uptake on days 1-3 postmarathon still remain far below the premarathon maximal oxygen uptake, due probably to muscle dysfunction such as an impairment of muscular strength and work capacity and a persistence of muscle soreness.

REFERENCES

- Costill, D.L., H. Thomason, and E. Roberts, 1973 : Fractional utilization of the aerobic capacity during distance running. *Med. Sci. Sports*, 5 : 248-252.
- Pollock, M.L., 1977 : Submaximal and maximal working capacity of elite distance runners. Part I : cardiorespiratory aspects. *Ann. N.Y. Acad. Sci.*, 301 : 321.
- Sherman, W.M., D.L. Costill, W.J. Fink, F.C. Hagerman, L.E. Armstrong, and T.M. Murray, 1983 : Effect of a 42.2-km footrace and subsequent rest or exercise on muscle glycogen and enzymes. *J. Appl. Physiol. : Respirat. Environ. Exercise Physiol.*, 55 : 1219-1224.
- Sherman, W.M., L.E. Armstrong, T.M. Murray, F.C. Hagerman, D.L. Costill, R.C. Staron, and J.L. Ivy, 1984 : Effect of a 42.2-km footrace and subsequent rest or exercise on muscular strength and work capacity. *J. Appl. Physiol. : Respirat. Environ. Exercise Physiol.*, 57 : 1668-1673.
- Tanaka, K., and Y. Matsuura, 1984 : Marathon performance, anaerobic threshold, and onset of blood lactate accumulation. *J. Appl. Physiol. : Respirat. Environ. Exercise Physiol.*, 57 : 640-643.

- Tanaka, K., Y. Matsuura, A. Matsuzaka, K. Hirakoba, S. Kumagai, S. Sun-O, and K. Asano, 1984: A longitudinal assessment of anaerobic threshold and distance-running performance. *Med. Sci. Sports Exerc.*, 16: 278-282.
- Tanaka, K., T. Yoshimura, S. Sumida, R. Mitsuzono, S. Tanaka, Y. Konishi, H. Watanabe, T. Yamada, and K. Maeda, 1986: Transient responses in cardiac function below, at, and above anaerobic threshold. *Eur. J. Appl. Physiol.*, 55: 356-361.

(Received February 15, 1988)