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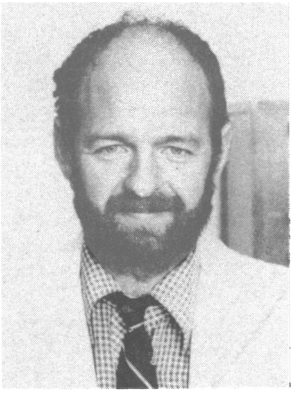

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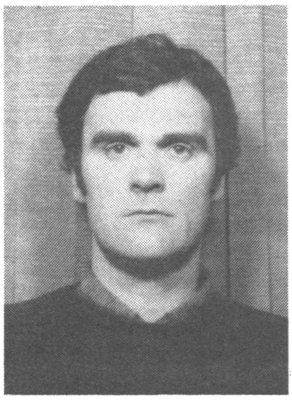

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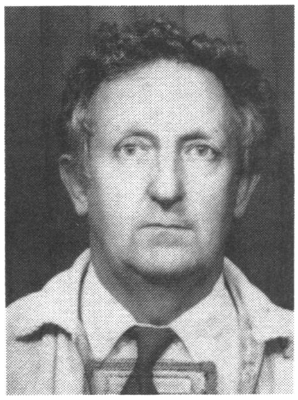

J. Thompson

RECTAL TEMPERATURE AFTER MARATHON RUNNING

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ABSTRACT

Rectal temperature was measured in 62 male runners who competed in the 1983 Dundee marathon race: all measurements were made immediately after the race. Competitors' times were noted at 5, 10, 15 and 20 miles (8.0, 16.1, 24.1, 32.2 km) and at the finish (26.2 miles, 42.2 km). Mean finishing time of the group was 3 hr 33 min ± 48 min (mean ± S.D.; range = 2 hr 17 min-5 hr 11 min). Mean running speed of the group decreased progressively as the distance covered increased. Mean post-race rectal temperature was 38.7 ± 0.9°C (range 35.6-40.3°C). The post-race temperature was correlated ($p < 0.01$) with the time taken to cover the last 6.2 miles (10 km) of the race, but not with the overall finishing time ($p > 0.05$). Only the fastest runners were able to maintain an approximately constant pace throughout the race, whereas the slower runners slowed down progressively. The runners with the highest post-race temperature, although not necessarily the fastest runners, also tended to maintain a steady pace throughout. The runners with the lowest post-race temperature slowed down markedly only over the last 6.2 mile section of the race. The results clearly indicate that runners forced by fatigue or injury to slow down in the latter stages of races held at low ambient temperatures may already be hypothermic or at serious risk of hypothermia.

Key words: Marathon running, Temperature regulation, Hypothermia.

INTRODUCTION

Although hyperthermia and the associated problems of fluid and electrolyte balance have long been accepted as potential hazards for athletes engaged in events of long duration, it is only within recent years that the danger of hypothermia associated with marathon running has been widely recognised. This is perhaps best demonstrated by the prominence given to the risk of hypothermia in the 1984 revision of the American College of Sports Medicine position statement on heat injuries in distance running; in the 1975 position statement, no mention of hypothermia was made.

Several factors may contribute to the development of hypothermia during prolonged exercise, but this can occur only when the rate of heat loss from the body exceeds the rate of heat production and heat gain. The most obvious contributing factors are adverse environmental conditions, inadequate clothing and a low rate of heat production resulting from a slow running speed. We have previously suggested that low post-race rectal temperatures are most likely to be observed in runners who have completed the second half of the race more slowly than the first (Maughan, 1985). The present study was undertaken to investigate in more detail the relationship between running speed and post-race rectal temperature in elite and non-elite marathon runners.

METHODS AND MATERIALS

All measurements were made at the Dundee marathon which was held over the standard distance of 26.2 miles (42.2 km) on Sunday, 24th April, 1983. Weather conditions were favourable for an event of this nature, the temperature being fairly low throughout with only a light wind and light rain in the early stages of the race.

The measurements of temperature, humidity and wind speed shown in Table I were obtained from the local meteorological office situated some 25 km away. The race started at 11 a.m. and the last of the subjects of this study completed the race shortly after 4 p.m.

A total of 1,343 competitors started the race: of these 1,258 (93%) successfully finished, of whom 62 males took part in the present study. Mean age of these runners was 30 ± 6 years (± S.D.), with a range from 19-45 years. Mean finishing time was 3 hr 33 min ± 48 min. The fastest subject in the present study (who was also the winner of the race) finished in a time of 2 hr 17 min; his average running speed was, therefore, more than twice as great as that of the slowest subject who completed the distance in a time of 5 hr

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TABLE I

Environmental conditions during the Dundee marathon

Time	Air Temperature (°C)	Relative Humidity (%)	Wind Direction	Wind Speed (m.s⁻¹)
1100 h	6.6	100	North-easterly	5
1200 h	7.2	98	North-easterly	4
1300 h	7.0	99	Easterly	4
1400 h	8.6	88	South-westerly	3
1500 h	11.1	73	South-westerly	4
1600 h	11.8	71	South-westerly	4

11 min. Fluid intake was allowed ad libitum during the race and no effort was made to record the volumes consumed.

The race started and finished at the same point; all measurements were made in a building immediately adjacent to the finish area. Upon completion of the race, the volunteers were led to a screened off area where measurements of rectal temperature were made by two investigators. All measurements were made using mercury-in-glass clinical thermometers which had previously been calibrated. As reported in a previous study, (Maughan, 1985), measurements were made by one of the investigators who inserted the thermometer to a constant depth of 7 cm beyond the anal margin and recorded the temperature after 4 minutes had elapsed. Every effort was made to ensure that the delay between a subject completing the race and the measurement of rectal temperature was as short as possible, but it was inevitable that 1-2 minutes elapsed between completion of the race and insertion of the thermometer.

Finishing time of the competitors was obtained from the official race results sheet. Intermediate times at the 5, 10, 15 and 20 mile (8.0, 16.1, 24.1 and 32.2 km) points were recorded by groups of volunteers who were stationed at each of these points. All measurements of distance were certified by the race organisers, who also provided synchronised digital clocks at each of the timing points.

Statistical analysis of the data was performed using a commercially available package (Daisy) run on an Apple IIe microcomputer. Student's t-test for paired or unpaired data was used where appropriate; linear regression was calculated by the method of least squares.

TABLE II

Intermediate and finishing times for 62 male competitors running the Dundee marathon. Competitors were aged 30 ± 6 years (mean ± S.D., range 19-45 years)

Distance Miles (km)	Time (min) Mean	S.D.	Range
5 (8.0)	36	8	25- 51
10 (16.1)	75	14	53-102
15 (24.1)	115	22	81-157
20 (32.2)	157	32	106-215
26.2 (42.2 finish)	213	48	137-311

RESULTS

The mean post-race rectal temperature of the group of runners was 38.7 ± 0.9°C. A wide range of temperature was recorded, the highest being 40.3°C, in a runner who completed the race in a time of 3 hr 33 min. The lowest temperature (35.6°C) was found in a runner who took 3 hr 7 min to finish the race. The post-rectal temperature of the fastest (2 hr 17 min) finisher was 39.4°C, which was not very different from the value of 38.6°C recorded on the slowest finisher in the study who achieved a time of 5 hr 11 min. Two runners were found to have a post-race temperature of 40°C or more, whereas three runners had temperatures of less than 37°C. Statistical analysis of the data showed that post-race rectal temperature was not significantly correlated with the time taken to complete the race ($r = -0.23$; $p > 0.05$). A significant relationship was, however, observed to exist between post-race temperature and time taken to complete the last 6.2 miles (10 km) of the race ($r = -0.33$; $p < 0.01$; Fig. 1).

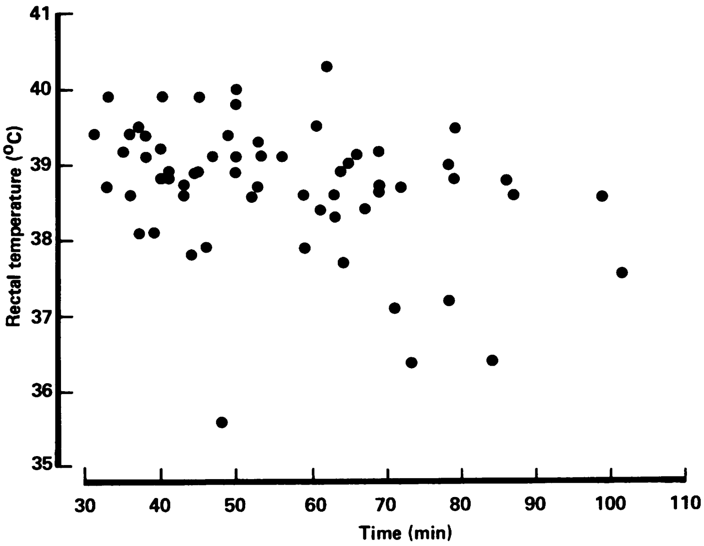

Fig. 1: Post-race rectal temperature was significantly ($p < 0.01$) correlated with the time taken to cover the last 6.2 miles (10 km) of the race.

Considering only the fastest 10 finishers from the group of 62 subjects, who recorded a mean time of 2 hr 27 min ± 8 min, mean post-race rectal temperature was 39.1 ± 0.5°C, with a range from 38.1 to 39.9°C; these runners were able to maintain an approximately constant pace throughout the race and certainly showed no tendency to slow down in the latter stages (Fig. 2). By contrast, the 10 slowest finishers completed the race in a time of 4 hr 48 min ±13 min, and recorded post-race rectal temperatures of 38.3 ± 1.0°C, with a range of values from 36.4 to 39.5°C (Fig. 2). These runners slowed down progressively as the distance covered increased; this deceleration, however, was no more marked towards the end of the race than in the earlier stages.

If only the 10 runners having the highest post-race rectal temperatures are considered, these can be seen to be a rather heterogenous group with respect to performance, the mean finishing time being 3 hr 16 min ± 50 min (range 2 hr 21 min-4 hr 54 min). Post-race rectal temperature of this group was 39.8 ± 0.3°C (range 39.4-40.3°C). As with the group of fast runners, these subjects seemed ablė to maintain a fairly steady pace throughout the race with only a very slight gradual deceleration (Fig. 3). The 10 runners with lowest temperatures after the race finished in 3 hr 51 min ± 43 min (range 2 hr 48 min-4 hr 54 min); post-race temperature was 37.2 ± 0.8°C (range 35.6-37.9°C). This group of competitors ran at a speed which was slightly slower than average throughout the race, but slowed down dramatically over the last 6.2 miles of the race.

DISCUSSION

The present study confirms that hypothermia rather than hyperthermia is likely to be a problem among marathon runners competing in races held on days when the wind chill factor is equivalent to an air temperature of less than

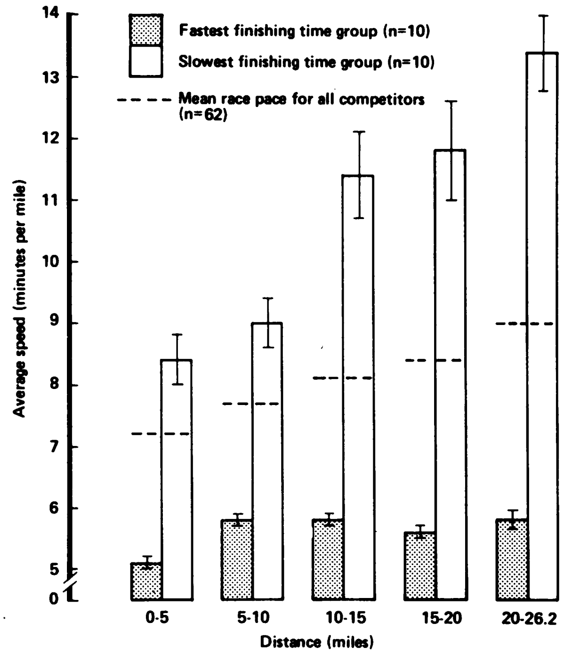

Fig. 2: There was a tendency for runners to decrease their speed as the race progressed, but this did not appear to apply to the fastest runners.

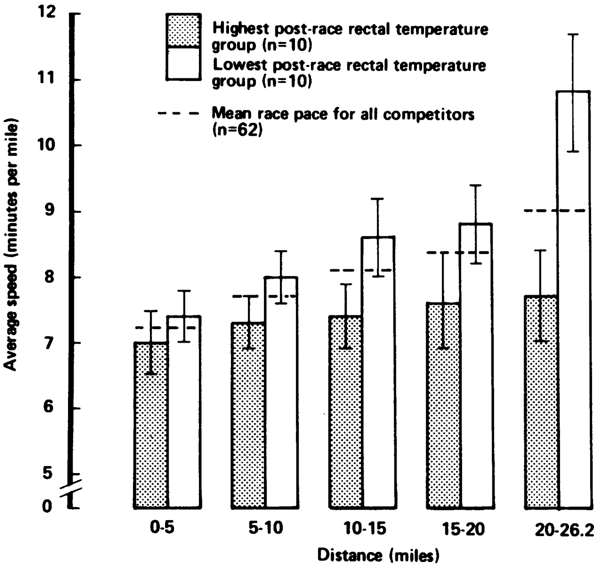

Fig. 3: The runners having the highest post-race rectal temperature, showed a slight progressive deceleration as the distance covered increased. By contrast, the runners with the lowest post-race rectal temperature slowed down markedly in the closing stages of the race.

12°C and a head wind greater than 3 m.s^{-1}. This appears to be particularly true for those runners who decrease their running pace — presumably due to fatigue — in the last few miles of the race. All but the fastest runners tend to cover the first few km at a pace which is higher than that which can be sustained for the full duration of the event. For the slowest finishers in the present study, the average speed over the last 6.2 miles (10 km) of the race was 13.4 minutes per mile (8.33 minutes per km), corresponding to little more than a brisk walk, and yet this group generally had an elevated body temperature. The pattern of deceleration of these runners was gradual throughout the race, in contrast to the runners with the lowest post-race temperatures who slowed markedly in the closing stages.

The present results are in contrast to those obtained from most previous studies of thermoregulation in runners. These reports have generally identified the risk of hyperthermia as a significant danger for participants in endurance running events.There appear to be two reasons for failure to identify hypothermia as a hazard. Firstly, most previous studies have studied only elite competitors who are generally able to maintain a high running speed for the full distance of the race. Secondly, ambient temperature in the present study was much lower than was the case in most other investigations. Costill (1972) reported a rectal temperature of 41.3°C in a marathon runner who had dropped out of a race; ambient temperature was 31°C. Even at more moderate environmental temperatures (23°C), Pugh et al (1967) observed that several runners had rectal temperatures in excess of 40°C upon completion of a marathon race and that in one case, temperature exceeded 41°C. At races held over shorter distances, relatively high ambient temperatures may also predispose competitors to hyperthermia; among almost 3,000 competitors in two Canadian 10 km races where the ambient temperatures were 24°C and 32°C, Hughson et al (1980) observed 26 cases of heat injury which were sufficiently serious to require hospitalisation. The temperature on the day of the Dundee race did not exceed 12°C, and this relatively low ambient temperature together with a head wind for the major part of the distance is probably largely responsible for the absence of cases of hyperthermia among the subjects studied. In addition the race organisers provided numerous drinking stations at intervals along the route, and all runners were encouraged to make frequent use of these. Sutton et al (1972), however, did report that several competitors in a 14 km 'fun run' held at an ambient temperature of 15.6°C suffered from hyperthermia in spite of the relatively short distance and low temperature.

The present findings are, however, very similar to those obtained at an earlier marathon held under similar conditions (Maughan, 1985). At that race, held at an ambient temperature of 10-12°C, mean rectal temperature measured on 59 subjects immediately after the race was 38.3 ± 0.9°C (range 35.6-39.8°C). The population under study was similar in both cases, the mean finishing times and the range being very close. In both studies, the relationship between post-race rectal temperature and the time taken to complete the race was weak, and not statistically significant. A number of competitors in each study was found to have a temperature lower than the accepted normal resting value of 37-38°C upon completion of the race.

The lack of a significant relationship between finishing time and post-race temperature is surprising. The steady state core temperature attained during exercise is related to the relative work load, expressed as a percentage of maximum oxygen uptake ($\dot{V}O_2$ max) (Saltin and Hermansen, 1966). The faster runners in a marathon race not only work at a higher absolute work load, but also at a higher percentage of $\dot{V}O_2$ max (Maughan and Leiper, 1983): there is a linear relationship between average racing speed and the percentage of $\dot{V}O_2$ max necessary to sustain that speed. The faster male runners, who finish the race in 2½ hours run at a speed which requires an oxygen consumption of about 52 ml.kg^{-1}min^{-1}, corresponding to about 75% of $\dot{V}O_2$ max. For the slower runners, who take around 5 hours to cover the full distance, mean oxygen consumption is about 31 ml.kg^{-1}min^{-1} representing only about 63% of $\dot{V}O_2$ max. These results suggest that post-race rectal temperature should be related to finishing time, but assume a constant pace throughout the race. The present results show that this consumption is not valid. The post-race temperature as measured in this study probably reflects only the running speed over the last 30 minutes or so of exercise (Nielsen, 1938).

One competitor in the Dundee race, who was not part of the present study, was forced by severe fatigue to stop running after completing about 22 km of the race in a time of approximately 1 hr 40 min. After waiting some time for transport back to the finishing point, he arrived, still wearing only his running gear consisting of vest, shorts and shoes, in a state of collapse. On arrival at the first-aid point, rectal temperature was measured by one of the investigators in the present study and was found to be 33.4°C. This finding is similar to that reported by Ledingham et al (1982) who reported a rectal temperature of 34.3°C in a runner who collapsed near the finishing line; again there was some delay between the cessation of exercise and the measurement of rectal temperature.

In conclusion, these results confirm that hypothermia is potentially more of a problem than hyperthermia in marathon races held in cool climates, particularly among the slower runners. Those most at risk are runners whose speed decreases sharply at any stage of the race.

ACKNOWLEDGEMENTS

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BOOK REVIEW

Title: **PATIENT EXAMINATION AND ASSESSMENT FOR THERAPISTS**
Authors: Margaret Hollis and Peter Yung
Publishers: Blackwell Scientific Publications
Price: £7.20 130 pages with Index Soft cover

In this pocket sized manual, Miss M. Hollis and Mr. P. Yung (the past and present Principals of Bradford School of Physiotherapy) have simply and clearly explained the procedures of patient examination and assessment.

Each chapter is headed by a delightful cartoon and caption, reminding the reader of the need to "consider the whole patient".

The purpose of the book is to remind every physiotherapist what, why, when, how and where he must look and question, to discover his patients' problems. The how to deal with them most effectively, so creating good relationships and establishing effective treatment regimes.

The chapters cover the philosophy, preparation and management of the patient and the basic and specific body area examination procedures. It reviews the simple but important tests and measurements which may be necessary and sums up normal and abnormal functional activities.

To some, this book might seem too simple, but I would like to recommend it strongly as a valuable addition to any Physiotherapy Department bookshelf.

Margaret John, MCSP, SRP