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FACTORS AFFECTING PERFORMANCE DURING AN ENDURANCE RELAY

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ABSTRACT

A successful attempt by Edinburgh Athletic Club on the world record for the 24-hour 10-man x 1 mile relay is reported. The effects of a variety of factors on the performances of the athletes are assessed, and some physiological changes noted. In the light of these observations recommendations are made to help the planning of future record attempts.

INTRODUCTION

Relay racing is nothing new in the British athletics scene, the numbers of runners and distances involved varying from the 4 x 100 metres track relay through to the 6 x 5 kilometres road and cross-country relays. The 12-man London to Brighton relay of 50 miles (80 kilometres), once the highlight of the season, has now been replaced by the A.A.A.'s National 12-man 50 mile relay held annually at Sutton Coldfield. Recently there has been an upsurge in long distance relay racing throughout the world. The Kenyans have been involved in fund-raising relays; one lasted 24 hours with 40 runners each doing a half-mile at a time. In America the 24-hour relay has been tried by teams ranging in number from 2 to 300 runners! From all this activity it is the 24-hour 10-man x 1 mile relay that has been the most hotly contested. The rules are simple. The team must have ten members, each of whom has to run one mile, the running order of the team remaining unchanged. If a member has to drop out he is not allowed to re-enter and the team has to continue without him. The aim is to go as far as possible in 24 hours. Records as on 28 September 1974 are shown in Table I. The scale of the race is immense when it is considered that the longest track race is 10,000 metres (6 miles 376 yds.), a mere 25 laps lasting about 30 minutes, and the longest Olympic running event is the marathon of 26 miles 385 yards, lasting just over 2 hours.

At 18.00 hours on 28 September 1974, at Meadowbank Sports Centre, Edinburgh, a team from Edinburgh Athletic Club set off for an attempt on the 24-hour 10-man x 1 mile relay record. As this was an endurance event of some severity, medical and physiotherapy cover was present. It was decided to carry out an investigation into factors affecting the performance of the runners and the effects of the race on the runners themselves. Since the men were attempting to set a new world record, investigations which might adversely affect performance had to be avoided and this excluded continuous recording equipment, tests requiring blood samples and the use of exercise tolerance tests before the event.

The members of the team were J. Alder, J. Dingwall, D. Gunstone, P. Hay, D. Knowles, R. Knowles, A. Matheson, J. Patton, A. Wight and J. Wight.

Preparations and Investigations

The runners were all known middle-distance runners who had been training and competing for many years. They underwent a clinical examination before the event to exclude any acute illness which might make participation in the attempt inadvisable. The decision to withdraw a runner was also to be made on clinical grounds if there was evidence of physical or mental distress. The weights of the athletes were recorded and urinalysis performed for blood and protein using haemocombistix. These tests were repeated after the event. Pulse rates were recorded 5 minutes before and 5 minutes after completing the first mile each athlete ran, this procedure being repeated at approximately 23.00, 03.00, 11.00 and 15.00 hours. The Physiotherapist's room at the sports centre, which was part of the athletes' rest room, was adequately stocked with equipment, e.g. benches, selective treatment unit, vibrator, infra-red and ultra-violet lamps, along with ample supplies of first aid materials. Unfortunately there was only one Physiotherapist/masseur available and it was decided that due to the time required each runner would be given massage

only after every third time he was on the track, or when injury, soreness or fatigue prevailed.

The attempt was aimed to start at 18.00 hours so that the runners were still relatively fresh during the depressing hours of darkness. Each lap time and mile time were recorded for each runner as required by the regulations for the event.

OBSERVATIONS AND DISCUSSION

(a) The attempt

Although a runner was withdrawn after 154 mi. because of physical distress, the other nine completed the 24 hours and successfully beat the existing world record for all classes of teams (Table I). The distance covered in each hour is shown in Table II, with the performances of the individual runners in Table III. The runners averaged 4,50.27 min./mi. and times of 5 min. or slower were recorded for only 15 of the 297 miles. The average for 10 miles was 48,22 min. with the fastest (47,1 min.) for miles 29-38 between 20.12 and 20.59 on the 28th and the slowest (49,10 min.) for miles 245-254 between 13.38 and 14.27 on the 29th.

TABLE I

World Records, as at 27th September, 1974, for the various recognised team categories

	Average Distance per hour	Total 24 hr Distance	
World Best for a Composite Team	12mi 525 yd	295mi 269 yd	20 July 1970
U.S. Olympic Training Camp (Washington)	19.792 km	474.989 km	
World Best for a Club Team	12mi 382 yd	293mi 378 yd	7th & 8th Oct. 1972
Sale Harriers (England)	19.661 km	471.871 km	
World Best College Team	11mi 991 yd	277mi 896 yd	21st March 1971
Furman University (South Carolina)	18.608 km	446.595 km	
World Veterans Best (Over 40's)	10mi 1398 yd	259mi 108 yd	6th Nov. 1971
Seniors T.C. (California)	17.371 km	416.907 km	
World Women's Team Best	8mi 1739 yd	215mi 1250 yd	9 June 1972
Redwood City Striders (California)	14.465 km	347.142 km	
Edinburgh Athletic Club	12mi 707 yd 19.958 km	297mi 1145 yd 479.009 km	28th Sept. 1974

TABLE II

Hourly Distances During the 24 Hours

	TIME	Miles	Yards	Ranking	kilometres
Saturday	1800-1900	12	985	5	20.212
	1900-2000	12	1364	1	20.559
	2000-2100	12	1222	3	20.429
	2100-2200	12	1293	2	20.494
	2200-2300	12	1097	4	20.315
	2300-2400	12	834	7	20.074
Sunday	2400-0100	12	867	6	20.104
	0100-0200	12	789	8	20.033
	0200-0300	12	777	10	20.022
	0300-0400	12	692	11	19.944
	0400-0500	12	547	14	19.812
	0500-0600	12	587	13	19.848
	0600-0700	12	669	12	19.923
	At this point one runner was withdrawn				
	0700-0800	12	418	21	19.694
	0800-0900	12	359	24	19.640
	0900-1000	12	500	17	19.769
	1000-1100	12	429	20	19.704
	1100-1200	12	498	18	19.767
	1200-1300	12	458	19	19.730
	1300-1400	12	367	23	19.643
	1400-1500	12	395	22	19.673
	1500-1600	12	542	15	19.807
	1600-1700	12	511	16	19.779
	1700-1800	12	785	9	20.030

(b) Medical Observations

The vital statistics of the runners are shown in Table IV and the pulse rates in Table V. It was noted that the athletes with the smallest difference between pre- and post-run pulse rates, and the athletes with the lowest pulse rate overall, were mature marathon runners with personal best marathon times of about 2 hr 15 min. The steadiness of the individual performances, and the stable post-run pulse rates were a tribute to the fitness of the athletes. Indeed, one athlete, after completing his 22nd mile in under 5 minutes, had a pulse rate of 132 as he came off the track, but within 5 minutes it had fallen to 67. All the runners lost weight (Table IV), and all showed proteinuria after the event. The greatest proteinuria was present in the three who showed the greatest weight loss (3.2 kg., 3.2 kg. and 4.6 kg.). There was no relationship with age, height or initial weight. This finding of universal proteinuria suggests that some of the weight loss might have been due to protein loss and not merely loss of fluid, and this is supported by the

TABLE III

Analysis of Individual Performances

Runner	Total Miles	Fastest Mile		Miles within 5 sec of fastest	Slowest Mile		Miles within 5 sec of slowest	Average Mile Time
		Time	No.		Time	No.		
1	32	4 min 38 sec	4	1-7	5 min 0 sec	14	14, 18-20, 22, 23, 28-31	4 min 50.28 sec
2	32	4 min 38 sec	2, 4	1-6	4 min 56 sec	30	17, 21, 22, 24, 28-31	4 min 46.7 sec
3	31	4 min 42 sec	4	1-5, 7	5 min 04 sec	30	29, 30	4 min 52.4 sec
4	16	4 min 45 sec	1	1-5, 16	5 min 20 sec	15	–	4 min 57.6 sec
5	31.65	4 min 41 sec	4	4, 8, 31	4 min 59 sec	23, 24	20-27, 17	4 min 50.5 sec
6	31	4 min 41 sec	2, 5	2-6, 8, 31	5 min 04 sec	26	25, 26	4 min 51.12 sec
7	31	4 min 44 sec	5, 6	1-6, 8-11	5 min 01 sec	26	16, 18-21, 23-26, 28-31	4 min 52.84 sec
8	31	4 min 37 sec	30	2-6, 8, 11, 12, 16, 30, 31	4 min 55 sec	18	18, 29	4 min 43.64 sec
9	31	4 min 41 sec	3	1-7, 9, 10	4 min 56 sec	29	17-30	4 min 49.54 sec
10	31	4 min 44 sec	1, 2, 4	1-7, 9, 15	5 min 02 sec	18	17, 18, 25	4 min 51.74 sec

TABLE IV

Summary of Anthropometric Measurements and Urine Tests

Runner	Age	Height		Pre-run Weight		Height/Weight Ratio		Post-run Weight		Weight Loss		Weight loss in relation to height		Post run	
		in	cm	lb	kg	lb/in	g/cm	lb	kg	lb	kg	lb/in	g/cm	Proteinura	Haematuria
1	34	67	170.2	141	64	2.1	376	131	59.4	10	4.6	0.15	27	++	–
2	25	68	172.7	142	64.4	2.1	373	138	62.6	4	1.8	0.06	10.4	+	–
3	24	68½	174	125	56.7	1.8	326	118	53.5	7	3.2	0.10	18.4	++	–
4	24	72	182.9	156	70.8	2.2	387	151	68.5	5	2.3	0.07	12.6	+	–
5	19	67¼	170.8	126	57.2	1.9	335	121	54.9	5	2.3	0.07	13.5	+	–
6	19	66¼	168.2	123	55.8	1.9	332	117	53.1	6	2.7	0.09	16.1	+	–
7	31	72	182.9	160	72.6	2.2	397	153	69.4	7	3.2	0.10	17.5	++	++
8	22	68½	174	130	59	1.9	339	124	56.2	6	2.8	0.09	16.1	+	–
9	31	68	172.7	129	58.5	1.9	339	125	56.7	4	1.8	0.06	10.4	+	–
10	29	67	170.2	118	53.5	1.8	314	114	51.7	4	1.8	0.06	10.5	+	–
Means	26	68.4	173.9	135	61.2	2.0	352	129	58.6	5.8	2.6	0.08	15.2		

observation of one runner that his weight did not return to its pre-race level for two weeks. Two of the runners were 183 cm. tall and both weighed over 70 kg. One of these had to be withdrawn because of physical distress, and the other was the only runner to show haematuria after the event. The smaller/lighter men seemed to suffer less.

An examination of Tables II and III shows that the greater proportion of slow miles and small hourly mileages occurred later in the event. These facts, combined with a gradual rise in resting pulse rates (Table V), appear to indicate the effects of progressively increasing fatigue, but the lack of uniformity of times and distances suggests that other factors were also affecting performances. These factors could have been circadian, diurnal (the presence or absence of daylight) or psychological (such as apprehension, elation or dejection). Ap-

TABLE V

Pulse rates (beats/min) of the Runners 5 Min Before and 5 Min After Running 1 Mile at the Times Stated

Approximate time in event		1800, 10 ran i.e. 1st mile	2300, 10 ran	0300, 10 ran	1100, 9 ran	1500, 9 ran
(i) BEFORE run	Mean	57	71	71	75	77
	Range	51 to 64	54 to 84	57 to 87	58 to 88	66 to 99
(ii) AFTER run	Mean	82	79	84	82	84
	Range	69 to 92	64 to 93	64 to 100	67 to 102	54 to 105
difference between (i) and (ii)	Mean	24.5	8.1	12.4	7.33	6.5
	Range	7 to 38	−4 to +22	2 to 15	−4 to +23	−12 to +33

prehension was probably felt by each runner worried as to his individual ability to complete the event. This was reflected in the below average distance covered during the first hour, and the drop immediately after the runner was withdrawn. Until this point each athlete had run every tenth mile with a gap of about 45 minutes, but after 164 miles he had to run every ninth mile with the gap reduced to about 40 minutes and the effect was immediate. Hour 08.00 to 09.00 was the worst, probably being a compound of the effects of apprehension following the withdrawal of the runner and the depressant effect of the last hour of darkness. Certainly with the return of daylight the distance covered from 09.00 to 10.00 showed a marked improvement. Once the event had started the tension eased slightly and this showed in the hourly distances and the fact that, of the 9 runners who completed the relay, 12 of the 14 fastest personal miles occurred in the second to sixth miles. The effect of the removal of apprehension also showed in the last 3 hours when, despite severe fatigue, the distance per hour increased, especially during the final hour when it was the ninth longest of the race, even though the athletes were running their individual 31st and 32nd miles of the series. This effect was also noticeable in the runner who was withdrawn. He managed to produce a last mile (16th) within 4 seconds of his fastest and 31 seconds faster than his 15th. In fact the only runner with a slow final mile was also the only one to show haematuria, which possibly indicated real physical distress. There was no evidence of circadian rhythm factors affecting performance.

In the early stages of the attempt a few of the athletes slept during their 40 to 45 minutes rest period, but it was noted that they took a considerable time to wake up fully afterwards. It was felt that this could adversely affect their performances later, and so, during subsequent rest periods, they were not allowed to sleep but only to lie down with the feet raised higher than the head.

(c) Physiotherapy Observations

Most of the runners had never had a massage or physiotherapy before and had no idea of the potential benefits. This presented a slight problem in that nearly all had to be asked if they wished to go on the massage bench, instead of just coming for a massage. Also the athletes' legs had not been shaved before the attempt and this made massage more difficult. As time passed, the legs became more sore, greater care had to be taken during a massage to ensure that hair on the legs was not pulled. This was overcome by using more oil or cream than would normally have been used.

During the attempt it was impossible to keep statistics of the relationship between massage and mile times, but some of the runners who complained of tiredness, soreness or fatigue seemed to show an overall improvement, after treatment, of between 2 and 10 seconds on their next mile. Following a massage the greatest benefit noticed was a 12 second improvement over the athlete's previous mile. Showers, lasting 3 to 4 minutes, were only allowed at 10.30 and 14.30, when they replaced a massage. More showers might have been necessary had the weather been bad.

There were no real injuries during the attempt, but some of the complaints treated were tightening of the hamstrings, tenderness of the Achilles' tendon, pain in the chest muscles, spasm of the abdominal muscles and a "dull feeling" in the hip region. Most of the treatment was general massage, i.e. effleurage, petrossage and deep friction, but for the abdomen and hip, heat pads were used with the additional use of the vibrator on the hips. During the hours of darkness when the weather was cold, deep friction and menthol/wintergreen cream were used around the knee joint to improve circulation and provide warmth. One runner complained later in the attempt that during the first lap, his calf muscles felt dead causing him to run flat-footed, so that it was the

second or third lap before he got going. Ralgex spray on the two heads of the gastrocnemius and the Achilles' tendon seemed to help, but care had to be taken with the amount and frequency of use. The greatest subjective benefit was reported when the spray was used 5 or 6 minutes before going on the track. The runners' feet and shoes were treated with Scholl foot spray and dusting powder every time they came off the track, and blisters, or signs of them, were treated with surgical spirit, iodine and powder, which helped to keep any real foot injuries at bay.

One important factor not previously mentioned was the weather. Who ever would have thought that for a period of 24 hours there would be very little wind at Meadowbank? There was no rain, and while it was cold during the night the absence of a strong wind was of major importance.

RECOMMENDATIONS

1. The timing of an attempt

(a) The 24-hour period should start in the evening so that the runners are still reasonably fresh during the depressing hours of darkness.

(b) Consideration should be given to holding the attempt at a time of year with as few hours of darkness as possible, but the date chosen should not interfere with the athletes' preparations for other important events such as the S.A.A.A. and A.A.A. Championships or the Olympic Games.

(c) Meteorological records should be consulted and the attempt planned for a period which regularly produces conditions as near ideal as possible, i.e. no strong winds, no heavy rain and no extremes of temperature.

2. The attempt

(a) A target distance of 300 miles (482.8 km.) should be set and separate schedules based on this distance and the record of 297.65 miles (479.0 km.) should be drawn up. The schedules should be realistic and should relate to the actual times recorded at different stages of the above-mentioned record. They should not be based on average times which are misleading while the race is in progress.

(b) A team should be available to analyse the performance continuously e.g., the number of miles covered per hour, individual and cumulative times, 10 mile times, these being displayed in the rest room to keep the athletes informed. The status of the current attempt should be constantly related to the world record at the same stage and displayed in an easily understood form, e.g. after the first 10 miles the runners are 10 seconds faster than the world record, or after 3 hours the team is 400 yards ahead of the record. This would help to encourage the athletes especially during the night.

3. Medical

(a) Frequent pulse recordings related to the appropriate mile times might allow an assessment as to whether a poor mile time is due to fatigue or a psychological factor.

(b) Collection of all urine passed would allow the identification of the time of onset of proteinuria and/or haematuria, and a measurement of the total urinary protein loss. Electrolyte and other mineral changes could also be followed.

(c) The food intake of each runner could be recorded and an assessment made of the calorific and other nutritional intakes in relation to energy expenditure and performance.

4. Physiotherapy

(a) There should be a minimum of three physiotherapists available to ensure that each athlete can receive massage after each spell on the track.

(b) The athletes should shave their legs beforehand to facilitate massage.

(c) The athletes should have experience of massage and physiotherapy prior to the attempt.

(d) The athletes should take better care of their feet and if necessary have pedicure before the event.

ACKNOWLEDGEMENTS

This was a combined effort of athletes, time-keepers and support personnel who looked after such factors as feeding, and ensured that the correct athlete appeared on the track at the right time to take the baton. All are to be congratulated for the way they maintained their effort over the whole 24 hours.