

## Original Articles.

### OBSERVATIONS UPON LONG-DISTANCE RUNNERS.

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The final and culminating event in the Greek Olympian Games of 1896 was a foot race from the battlefield of Marathon to the stadium in Athens. The distance is 40 km., and the race was open to contestants from all parts of the world. The contest was won by a Greek shepherd, none of the French, German, English or American runners being in sight at the finish.

Several members of the Boston Athletic Association competed in those games. Since that time the association has held an annual Marathon run on Patriots' Day, over a course of equal length, from Ashland to the clubhouse on Exeter Street. In 1899 Drs. Williams and Arnold<sup>1</sup> reported the results of observations upon the contestants of that year; and the results of a series of similar observations during the past three years are here presented.

The examinations were made before the start and immediately after the finish of the contests. As some of the physical signs are modified or even entirely disappear very quickly after the race, it was necessary to have a large number of observers trained and assigned to particular duties. This resulted in a very large mass of data which it seemed best to condense and edit in the present form. The facts obtained, and the conclusions drawn, are given first. Methods and results of examinations and individual observations are added in greater detail for the benefit of future observers, or those specially interested in the subject.

The length of the course is twenty-four miles. The road is an average New England highway for two thirds of the distance, and for the remainder is the hard macadam surface characteristic of Boston's parkways. The course covers a rolling country, one or two hills, notably in Newton, being extremely long and trying. The general trend of the slope is downward.

No restrictions are put upon the runners, save that they shall proceed on foot over the specified route and shall not receive any assistance. They may, therefore, eat or drink what they please during the race. Each contestant is accompanied by an official guard on a bicycle, usually a volunteer from the Ambulance Service of the State Militia.

The costume of the runners is extremely light, consisting of cotton shirt and running pants and fairly heavy leather shoes or "sneakers," laced about the ankles and generally worn without stockings. The contestants were of various nationalities, including one Greek and one Mohawk Indian. Their ages ranged from sixteen years upwards; their occupations from laborers to students; their athletic standing was described by that somewhat elastic and much-discussed term "amateur." At the end of the race they were taken in the elevator to the dressing rooms of the clubhouse and immediately examined. After this they took a warm

bath, were given a rubdown and a light lunch, and shortly started for home, usually without assistance.

**Pulse.** — The rate was always increased in frequency, though the increase was often surprisingly small. It was least in the best-trained men and in those who finished slowly. In some instances it was almost as slow at the finish as at the start — notably in the winner of 1902. A very rapid pulse (over 150) was unusual.

A moderate irregularity was not infrequent.

An intermittent pulse was occasionally present.

A threadlike pulse of small volume was found in the rare cases of severe fatigue.

On the whole, the radial pulse was a fair index of the condition of the runner, though the rate alone often proved misleading.

**Weight.** — The estimation of the loss of weight was only approximate, for reasons given later. It varied from two to seven pounds, the extremes being one and ten pounds.

The amount lost was apparently determined by a combination of factors, including the original body weight and physical condition, the speed, the amount of solids and liquids consumed during the race and the atmospheric conditions.

**Temperature.** — Before the start, the mouth temperature showed not infrequent variation from the normal. This was usually a fraction of a degree, but in some instances reached 100.6°.

After the finish the mouth temperature was sometimes raised, often normal and occasionally subnormal. The rectal temperature, however, was invariably raised. In the entire three years only three exceptions were found to this rule, which will be discussed and explained below.

The difference between mouth and rectal temperature, taken simultaneously, was often surprisingly large, reaching in one instance 7°. The explanation of this interesting fact is that the men ran with open lips, and the forced and continuous breathing of cold air lowered the temperature of the mouth cavity.

The surface of the body was almost invariably cool and sometimes cold, but no distinct chills were observed.

**Sphygmographic pulse tracings.** — (1) Violent and prolonged muscular exercise invariably causes an alteration in the character of the pulse curve, as shown by the sphygmograph.

(2) This change in the character of the tracing is dirotic in nature and due to a lowering of arterial tension.

**Blood.** — The principal finding has a leucocytosis corresponding in intensity and in type with that observed in various inflammatory diseases.

**Hearts.** — Before the start, the hearts invariably showed enlargement, due mainly or wholly to hypertrophy. At the finish, in practically all cases, there was further slight enlargement, inferred to be the result of acute dilatation.

In some cases murmurs, generally systolic, were heard; some were heard at the start, and were considered to be the result of nervous excitement. Concerning the nature of a number heard at the finish there is considerable doubt; we do not feel justified in asserting that they were due to mitral regurgitation.

**Urines.** — The examination of the urine shows

<sup>1</sup>"The Effects of Violent and Prolonged Muscular Exercise upon the Heart." Phil. Med. Journ., June 3, 1899.

that in every case an active hyperemia is developed during the race, probably due largely to the irritation from the "toxins of fatigue," inasmuch as the blood pressure is not increased. This condition clears up quickly, as albumin and casts had disappeared in all the cases examined one week after the race.

The amount of urine for twenty-four hours is lessened, the color becomes higher, the specific gravity rises and the reaction becomes more intensely acid. Albumin appears in quantities varying from the slightest possible trace to a trace, and in the sediment we find in every instance hyaline and fine granular casts, a few coarse granular and epithelial casts and more or less blood, normal and abnormal, free and on casts. Rare brown granular casts are found in some sediments, and calcic oxalate crystals in the majority.

The urea is not increased after the race, but, on

and a contestant who had run fast for most of the course might slow down at the finish, particularly if he was far ahead of the next runner; his pulse rate would already have diminished materially before the end of the race. The third factor, the time elapsing before the observation, was also important. Two or three minutes are sufficient to change a very rapid to a moderately rapid pulse. This is shown in the following table, which compares the pulse rates after the 1900 race with the race in 1902. It will be seen at a glance that the 1902 average is faster, yet the time of the race and the condition of the men were about equal. The only varying factor was the time which elapsed before counting the pulse. In 1900 two or three minutes elapsed before the runner was stretched upon the table in the examining room; in 1902 the observer was in the elevator, and took the pulses as the men stepped from the street.

PULSE RATES AT FINISH.																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1900 . .	108	120	120	144	108	116	96	88	72	107	100	98	106	88	132	104	128	80	96	104
1902 . .	82	108	126	132	132	96	144	144	160	120	162	136	180	140	160	164	156	146		

the contrary, appears in the majority of cases to be less for the first twenty-four hours following the race than for the last twenty-four hours before the race. By the end of a week, however, it has again risen to normal.

The pulses of the first two men in 1902 were very slow, but, even with these exceptions, the pulses of 1902 were faster than 1900.

The following table compares the pulse rates before and after the race of 1900 :

BEFORE AND AFTER RACE, 1900.																	
1900	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Before . . . . .	100	80	72	76	84	84	72	104	84	72	80	82	80	86	92	120?	126
After . . . . .	108	120	120	144	116	88	100	98	100	88	132	104	80	96	104	134	116

The chlorides are markedly diminished after the race. It is probable that the output of uric acid is diminished, and that of phosphorus increased, but the results vary so much that no definite conclusions can be drawn.

PULSE, WEIGHT AND TEMPERATURE.

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Pulse. — The pulse rate seemed to depend on three factors: First, the condition of the heart itself; second, the character of the exertion, particularly in the last few minutes of the race; third, the time which elapsed between the actual finish and the observation of the pulse. The hearts best prepared for the contest seemed to have the slowest rates. These hearts were always hypertrophied, but were not overworked by excessive training. In each of the three contests, however, occasional slow pulse rates were observed in which the hearts were not in particularly good condition. These we believe to be the exception and not the rule. The second factor influencing the rate was very effective — a man may have covered the entire distance to within half a mile of the end at a slow rate of speed, and may then have run very fast either racing a neighbor or encouraged to make a creditable appearance before the thousands lining the sidewalks — his final exertion would send the pulse rate up enormously; whereas the reverse also occurred,

In this table there are three cases where the pulse at the start was as fast or even faster than at the finish. These men finished slowly, and a few minutes elapsed before the pulse was taken. At the start the men differed much in composure, many even of the veterans being extremely nervous; whereas at the finish, with few exceptions all were stolid with fatigue.

Weight. — These observations were less accurate than those of pulse or temperature, because they were open to the following sources of error: First, difference in scales; second, solids and liquids ingested during the race; third, small articles of clothing. As it is difficult to accurately calculate the first of these, and entirely impossible to estimate the second, it is obvious that the following figures can be accepted as only moderately accurate.

The extremes of one-half pound (one case) and one pound (one case) on the one hand and ten pounds (one case) on the other may be disregarded. Without doubt the first two were much influenced by the above-mentioned source of error. A large majority of the cases would be found to lie within the three- to six-pound limit. This was certainly a moderate loss, and though the time was three times that of a football game, and ten times that of the average four-mile boat race, not only the average but even the maximum loss was less than has been noted in either football or rowing. In general the heaviest men and those who ran fastest lost the greatest amounts, though there were many exceptions to this.

<sup>1</sup> These figures represent the position of the men at the finish.