OBSERVATIONS ON THE RECTAL TEMPERATURE AFTER MUSCULAR EXERCISE.

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THE temperature of the human body is of frequent interest to the medical profession; that it is increased by muscular exertion is well known, but a difference of opinion exists as to the normal extent of this increase, and also as to the degree to which the temperature may rise without producing ill-effects. By many it is thought that the extra amount of heat generated is met, as a rule, by a corresponding increase in the amount of heat lost, so that the resultant body temperature is but little if at all raised, and that should any great increase take place a number of characteristic symptoms ensue. This view is probably due to the method of taking the body temperature. Pembrey and Nicol¹ have shown that thermometers placed in the mouth or in the axilla give very unreliable results, particularly during cold weather and after muscular exercise. The most reliable method, although unfortunately not the most convenient, is per rectum. In this way very accurate readings are obtained, especially if care be taken to introduce the thermometer to the same extent in all readings. The figures given in the subjoined tables show that the increase in body temperature during hard muscular work is often very great, Table I showing that the rectal temperature of a healthy individual may reach as high as 105° F. (40.55° C.) without producing any untoward results.

TABLE I.

Subject.	Race.	Rectal Temperature.	Observations.
C. M. R.	220 yards (1st)	100.85° F.	½ min. after race.
A. C. P.	220 yards (1st)	100.95	Immediately after race.
"	Long jump (1st)	101.50	3 mins. after last jump.
W. V. F.	½ mile (1st)	101.10	Immediately after race.
"	½ mile (1st)	102.00	" " "
H. S.	½ mile (4th)	100.80	" " "
R. M. L.	½ mile (2nd)	100.80	" " "
"	1 mile (1st)	102.60	1 min. after race.
"	1 mile (1st)	100.20	After running from course.
"	5 laps (1½ miles) of three miles	102.10	After running from course.
J. F. P.	1 mile	103.00 (100° before race, stripped in dressing room)	Immediately after race.
"	7 laps (1½ miles) of three miles	100.00	After running from course.
H.	1 mile (2nd)	102.80	1 min. after race.
"	3 miles (1st)	103.60	2 mins. after race.
H. P.	1 mile (2nd)	102.80	Immediately after race.
"	3 miles (2nd)	103.80	" " "
"	3 miles (1st)	105.00 (101° before race, stripped in dressing room)	" " "

These observations were made by Dr. Leonard Hill and myself at the London Hospital and Inter-Hospital Sports of 1907. On both days the weather was moist and bleak, with cold winds blowing. The temperatures were taken as soon as possible after the events, the competitors running back to the dressing-room for that purpose. At the same time the blood pressure was determined by the new form of Hill-Barnard sphygmometer, and a sample of the alveolar air collected by Haldane's method (see *Proceedings of Physiological Society*, July 20th, 1907). It will be seen from the table that the longer the effort the higher the body temperature rose, although J. F. P. showed no rise after one mile or after seven laps of the three miles race. This perhaps may be accounted for by the fact that J. F. P. had good vaso-dilatation with

marked sweating after the races. H. P., on the other hand, had marked skin vaso constriction; this helps also to account for the temperature of 101° when stripped before the race.

TABLE II.

Subject.	Rectal Temperature.	Time after Match.
E. C. L.	102.60° F.	About 10½ minutes.
A. B. L.	103.40°	" 13 "
A. C. P.	103.20°	" 15 "
G. M. C.	101.25°	" 19½ "
H. G. M.	102.20°	" 22½ "
A. S. H.	102.00°	" 24 "
M. B. B.	101.60°	" 28½ "

The temperatures in Table II were taken after the Inter-Hospital Rugby Final on March 12th last from members of the winning team. The afternoon was sunny, fresh, and cool, with but little wind blowing. A thirty-second thermometer was used in taking the readings, and it was inserted for fifty seconds on each occasion. It is interesting to note also that each subject considered himself "quite cool now," and was exhibiting no signs of great warmth or dyspnoea; yet it will be seen that in every case, except, perhaps, that of G. M. C., the temperature was markedly raised, especially when allowance is made for the time which had elapsed since the cessation of hard muscular exercise.

Our best thanks are due to the athletes for the help given us in making these observations.

Pembrey and Nicol¹ found, as the result of 343 observations upon two healthy men, that the average rectal temperature over twenty-four hours was 98.24° F. (36.79° C.), so that most of the above figures show a substantial rise, although allowance must be made for the psychic condition of the individual upon such occasions. Most of the temperatures given above are higher than any so far noted for the effect of muscular exertion, that of 105° F. being easily the record for man. In the figures given by Pembrey,² Richet,³ and Tigerstedt⁴ there is no such temperature recorded.

Wunderlich cites one of 39.8° C. (103.1° F.), observed upon a runner, and Pembrey has recorded some almost as high after severe muscular exercise. Jürgensen had a temperature of 100° F. (37.8° C.) under the tongue after sawing wood, Vernet one of 101.48° F. (38.60° C.) after indulging in the same form of exercise. U. Mosso has recorded 38.8° C. (101.84° F.) after a hard walk, and Forel obtained a temperature of 39.13° C. (102.43° F.) by mountain climbing. Animals normally have a higher rectal temperature than man; it is subject, perhaps, to even greater variation. A well-marked increase has been noticed in horses after exercise (Hobday, Liska). Richet states that a dog's temperature rose from 39.2° C. (102.56° F.) to 41° C. (105.8° F.) from mere struggling; also that the temperature of a pigeon went up from 42.05° C. (107.69° F.) to 43.7° C. (110.66° F.) after flying while loaded with weights.

It is well known that many factors, such as food, age, sex, race, external temperature, besides muscular work, are held to play a part in determining the body temperature. It would appear, however, that muscular work is one of the most important. Indeed, Tigerstedt⁴ expresses the opinion that, allowing for modification by food and the external temperature, the diurnal variation observed in man is due to a difference in metabolic activity. If this were so we should expect a reversal of the variation in night workers. The observations on this point are somewhat discordant; Tigerstedt thinks this may be due to the difficulty of sleeping during the day owing to the lack of quietude, and perhaps also to the imperfect exclusion of daylight, factors which must certainly alter the quality of the sleep obtained. Galbraith and Sutherland Simpson⁵ have shown that such a reversal can be obtained in apes, and exists in night-flying birds. Osborne, too, has recently contributed some interesting observations made upon himself during a voyage from Australia to England, the evening maximum of the diurnal variation taking place rather in regard to local time than to that of the starting place (Melbourne). Although his figures do

not disprove the existence of a body periodicity, they tend to show the importance of muscular activity in determining the maximum of the diurnal variation.

The temperatures in the case of H. P. after the race are interesting, and as follows:

TABLE III.

Subject.	Time.	Temperature.
H. P.	After race 5 p.m.	105° F.
	5.45 p.m.	102°
	6.45 p.m.	101°
	7.45 p.m.	101.2°
	8.45 p.m.	100.4°
	Next day 12.15 a.m.	100.1°
	3.45 a.m.	98.6°
	8.15 a.m.	98.8°
	4.30 p.m.	100.2°

Any doubt as to the health of H. P. is dissipated by the fact that he was afterwards thoroughly examined by both physician and bacteriologist, and no signs of disease of any kind were found; moreover the subject continues in perfect health at the present time.

REFERENCES.

- ¹ Pembrey and Nicol: *Journ. of Physiol.*, vol. xxiii, p. 386. ² Pembrey: *Animal Heat*, Schäfer's *Textbook of Physiology* (1898), vol. i, p. 785. ³ Richet, Chaleur, *Dictionnaire de Physiologie* (1898), Tome III, p. 81. ⁴ Tigerstedt, *Wärmeökonomie des Körpers*, *Handbuch der Physiologie des Menschen*, Herausgegeben von W. Nagel (1906), vol. i, p. 557. ⁵ Galbraith and Sutherland Simpson: *Journ. of Physiol.*, Proceedings, vol. xxx, pp. xix, xx. ⁶ Osborne: *Journ. of Physiol.*, Proceedings, vol. xxxvi, p. xxxix.

CALMETTE'S OPHTHALMO-REACTION.*

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It is well known to you that if Koch's tuberculin, a proteid glycerine extract of tubercle bacilli, be injected into a healthy animal no reaction follows, but that if the animal be tuberculous the temperature rises from 2° to 6° F. This tuberculin test is constantly used to detect tuberculosis in cattle. Exactly the same is true in man, and in the hands of an expert the reaction is perfectly safe. Osler¹ states that tuberculin is used extensively at the Johns Hopkins Hospital, both in the medical and surgical wards, with the most satisfactory results and without harmful effects.† In adults a milligram is injected, and if this has no reaction a larger dose of 2 or 3 mg. is given after an interval of some days. There is often slight local irritation following the injection, and within from ten to twelve hours the febrile reaction begins, the temperature rising to 102° or 104°.

This reaction, although valuable in large hospitals having a highly-trained staff, is of no real use to the general practitioner. After the injection, which should be made early in the day, the temperature must be taken every three hours. Special care is necessary in all cases of tubercle of the lungs or of the larynx.² In spite of all precautions the patient may become really ill, and very untoward accidents have been recorded. Living tubercle bacilli have been found in the New tuberculin,³ so that extreme caution is necessary in its use. Those of you who have received injections of the typhoid or plague prophylactics will be able to form an idea of the feelings a patient would nourish towards his medical attendant who administered an injection of tuberculin for merely diagnostic purposes.

C. von Pirquet⁴ has found that in tuberculous individuals vaccination of the skin with tuberculin produces a local reaction marked by redness and swelling coming on forty-eight hours after the operation. Lignières⁵ has shown that scarification of the skin is unnecessary. If tuberculin be rubbed into the skin of a tuberculous person the reaction can be obtained, especially if the skin has just been shaved. V. Pirquet obtained a reaction in all but 11 out of 80 tuberculous children.

* Read before the Coventry Division of the British Medical Association.

† See also Schumacher's paper, *Zeitschrift für Augenheilkunde*, March, 1906.

Even this cuti-reaction is not one likely to be tolerated by the average patient, and, as it involves a breach of skin surface, it cannot be entirely devoid of danger.

Last June, Calmette,⁶ the well-known discoverer of anti-snake-bite serum, announced that if tuberculin be placed in the eye of a tuberculous subject a conjunctivitis is produced, whereas in a healthy subject there is no change. This has proved to be approximately correct. Calmette's serum can be obtained from Martindale in two forms, the liquid and the dry. The liquid form is now supplied in 0.5 per cent. strength, as the original 1 per cent. solution acted too violently in some cases. It is sent out in a pipette ready for use. All that is necessary is to break off the ends of the pipette and squeeze out the contents, which are enough for four or five patients. The solid form is supplied in a small tube, and it is only necessary to add 20 drops of sterilized water to make a 0.5 per cent. solution. If 10 drops be added we get a 1 per cent. solution, which is useful for a second trial in cases which have not reacted to the weak solution.

The patient's eyes must be carefully examined, and the condition noted in a book. It is essential that there be no pre-existing conjunctivitis, for the reaction would then be masked. One or two drops of the solution must be instilled into the lower cul-de-sac and the eye held open for a few seconds. If the subject be tuberculous the eye will begin to redden in about three hours, and lachrymation will be complained of. At about the sixth hour the caruncle begins to swell, and there may be a slight fibrous exudation which gathers in filaments in the lower conjunctival sac. The reaction reaches its maximum in from six to thirteen hours; there is no rise of temperature and no general malaise.

The inflammation may vary in degree from slight lachrymation, and an almost imperceptible enlargement of the caruncle, to a severe conjunctivitis which may last for several days, or in some cases even for weeks. But there is little danger to the eye unless it be affected with tuberculous disease, a rare ocular condition. Two cases were mentioned by Kalt to the Paris Ophthalmological Society, in which an old tuberculous condition was lighted up by a drop of tuberculin placed in the conjunctival sac.† M. Morax regarded these effects as mere unfortunate coincidences, for the serum has been constantly used to diagnose tuberculous conditions of the eye with no such bad results. In many cases some experience is necessary to decide whether the reaction be positive or not; a careful comparison should be made between the carunculae on each side.

The intensity of the reaction bears no relationship whatever to the severity of the tuberculous process.

It is now necessary to inquire: Is Calmette's reaction such a simple practical test that it can be used as a routine diagnostic method by the general practitioner? It is a safe reaction and a simple one; it hardly inconveniences the patient at all; but is it perfectly reliable? The answer is that it is a very useful aid to diagnosis; but occasionally its answer is, to say the least, equivocal. Cases have been recorded in which a severe reaction has been obtained in apparently healthy men,⁸ and the reaction has failed in undoubtedly tuberculous individuals.

My personal experience has been very favourable. I have tried it in 5 or 6 cases of iritis and choroiditis which I did not believe to be tuberculous in nature but which might have been, and not one of them reacted positively. In another case of eczema of the brow a severe reaction was obtained, and as the child was apparently healthy I regarded the indication as false. But I had to take the child into the wards again, and this time she had a typically hectic temperature. We have not been able to find any tuberculous focus yet, but I think that a hectic temperature taken with a positive ophthalmic reaction make the presence of tubercle very probable. A second trial gave no reaction, but probably the tube, which had been opened some ten days previously, was not active, for it failed to elicit a reaction from three undoubted cases of surgical tuberculosis, which have since reacted to a second tube of serum.

Calmette's reaction is useful in cases of cerebral compression. Some months ago we had two cases of undoubted cerebral disease in the wards lying side by side.

† Other cases have now been recorded. See *Archives of Ophthalmology*, March, 1908. Knapp records a case where interstitial keratitis followed the test.