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Part I.—Original Articles.

Electric Bath Treatment in 108 *Cases of Mental Disorder, controlled by Warm Baths in* 16 *cases; and the Results of an Inquiry into the Influence of the Baths upon the Excretion of Creatinine in certain of these.*

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I.—By EDWIN GOODALL.

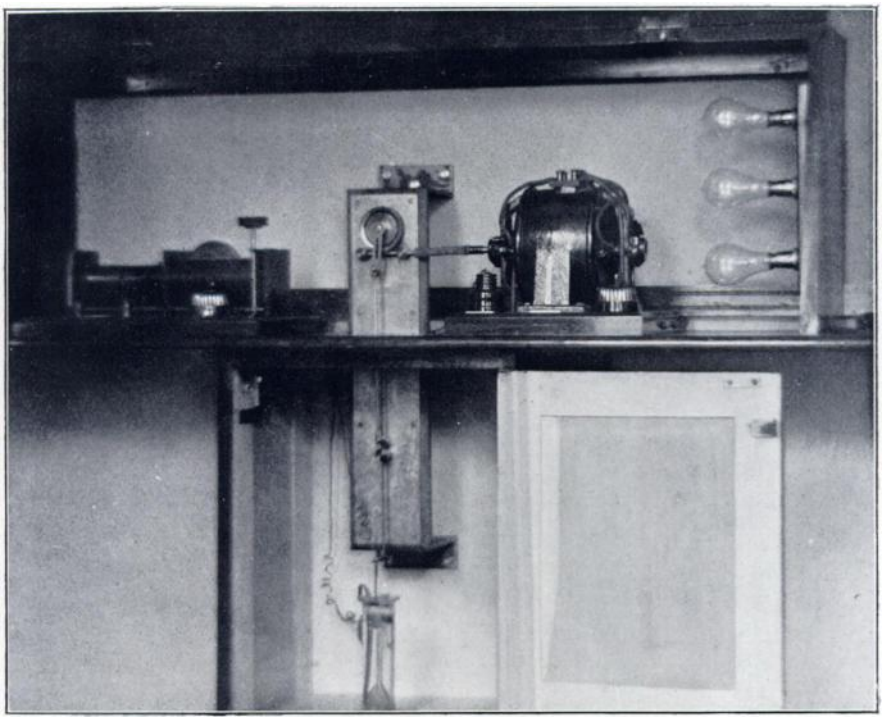
As long ago as 1901 my attention was called to the therapeutic value of electricity administered through the medium of warm water in a bath by my friend Dr. Lewis Jones, Physician in Charge of the Electrical Department, St. Bartholomew's Hospital, London. He considers this is the best means of employing electricity for general therapeutic purposes, describing it in his work on medical electricity as a method of great value whenever general stimulating and tonic effects are required. In this work will also be found reference to the treatment, some years since, of eighteen males and five females at Claybury Asylum by Dr. Robert Jones, with results which he considered satisfactory. In these induction coil currents were used in the bath. The method appeared to me likely to prove much more convenient and practical than the usual methods of faradism and galvanism, which do not lend them-

selves to the purposes of general as apart from special and local application. Largely, I think, for the lack of a convenient method of general application, electrical treatment has been almost discarded, at any rate in this country, in mental diseases. I hope in this communication to show that this therapeutic means is one which should not be neglected.

The form of current employed in this series of cases is that known as alternating and sinusoidal, in which the electrical current rises, not abruptly, but at a certain rate of progression, from zero to the maximum, falls again to zero, and flows in the opposite direction, the direction being altered several times a minute. Continuous current, obtained from the main or otherwise, is passed through a motor-transformer, rendered alternating, and thence through a sliding coil, whereby a low voltage (from 5–15 volts in the bath) is ensured.

Between 1901 and the summer of 1906, during which period I gave these baths in the course of my service as Medical Superintendent at the Joint Counties' Asylum, Carmarthen, I used no further modification, but during the past one and a half years, at the Cardiff City Mental Hospital, I have employed, in addition, the method of rhythmical variation recommended by Dr. Lewis Jones, and which he has lately described in the *Lancet*, November 13th, 1909.

Dr. Jones is of opinion that the results obtained are improved in this way. The mechanism I employ was contrived by our engineer. The current as it comes off the transformer is passed through a platinum wire, which is caused by means of a wheel-mechanism to dip slowly into water contained in an inverted funnel, and then is withdrawn. The current reaches its maximum when the point of the wire is in the widest portion of the funnel, where the resistance is lowest, and falls gradually to a minimum as the point recedes towards the top of the stem of the funnel, where the resistance is highest. The cycle is completed about fifteen times a minute. I need not go here into details of application; it suffices to say that the water in the bath is merely kept at a comfortable temperature, the patient's feet are in contact with a broad copper plate (the lower electrode), but his head is separated from the upper electrode by means of a back-rest of webbing. Each bath lasts twenty minutes, and for half this period I have been in the habit of changing the lower electrode to one of a paddle shape,



Apparatus for supply of sinusoidal current, with rhythmic variation, to bath, showing transformer on the right, wheel-mechanism, dipping wire, and inverted funnel in the centre, and sledge-coil on the left, from which current is taken to the bath.

To illustrate Mr. R. L. MACKENZIE-WALLIS's and Dr. EDWIN GOODALL's paper.

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which is passed up and down between the legs, between the arms and body, and about the body of the patient. After the bath the patient is kept in bed for at least an hour. Each course has consisted of eighteen to twenty baths. Patients are weighed once a week during the course. I have given these baths in 120 cases, making, I should say, some 2,000 baths in all. I now communicate observations made upon cases from the clinical point of view. In conjunction with my friend, Mr. Mackenzie Wallis, observations have been conducted from the purely scientific aspect, with a view to ascertaining the effect of the baths upon metabolism, as shown by the excretion of creatinine. Details of the cases treated are given at the close of this article in tabular form under the headings "Class of Case," "Weight Changes in Connection with Baths," "No. of Baths," "Results as regards Mental Recovery or Improvement."

Out of the 108 cases here dealt with, 62, or 57·4 *per cent.*, recovered, or showed mental improvement (as evidenced by speech and conduct) in connection with, and, as I believe, largely in consequence of, the baths. Of these 62 cases, 28 recovered and 30 improved, so that they in many cases became useful members of the asylum community, and 4 were discharged relieved.

As regards the kinds of mental disorder; 30 of the 62 which either recovered or improved showed varying degrees of melancholia, 9 acute or subacute mania, 5 melancholia with stupor, 5 stupor, whilst such conditions as post-maniacal confusion, delusional, hallucinatory, confusional states, and alternating states (mania—melancholia—stupor) claimed the remainder about equally. The bulk of the patients, therefore, were cases of melancholia. Of the 46 cases which did not improve 22 had melancholia, 11 showed degrees of stupor, 4 acute or subacute mania, 3 melancholia with stupor, 3 delusional insanity; the remainder were merely individual cases of mania, melancholia and confusion. Here again melancholia claimed the bulk of the cases.

In respect to age, all the patients were between the ages of 18 and 40, and mostly under 30.

Of the 62 cases with favourable results, 39, or 63 *per cent.*, were reduced generally as regards physical state, and 16 well nourished; no statement as to this point is made in 7.

Of the 46 not improved, 20, or 43 *per cent.*, were reduced, and 21 well nourished; no record made as regards 5.

In the cases with favourable results, therefore, the physically-reduced were more than twice as numerous as the well nourished, whilst in the unfavourable as many were well nourished on starting the baths as were reduced.

Of the 62 cases which did well, 50 showed a gain in weight, 9 a loss, and 3 no change in weight. Whilst in 19 the gain was less than 5 lbs., in 31 it was 5 lbs. or more, and in the bulk of these a good deal more. Of the 9 cases in which there was a loss this was less than 5 lbs. in 4; and where the loss was 5 lbs. or more the highest amounts lost were in two cases, 10 lbs. and 8 lbs. respectively. Further, of the 9 cases which lost weight 4 were persons well nourished at the outset. Of these 9 cases only 1 recovered, the others improving.

The gist of these figures, therefore, is that the great majority (80·6 *per cent.*) of cases which did well (recovered, improved) under this treatment gained weight, whilst 19·3 *per cent.* lost weight or remained stationary. Only 1 case which gave a recovery (as distinct from improvement) showed loss of weight.

Turning now to the 46 cases which did not improve, 15 showed a gain in weight, 26 a loss, and 5 no change. Whilst in 7 the gain was less than 5 lbs., in 9 it was 5 lbs. or more, but the maximum gain was not more than 7 lbs., and this in only 2 cases. The amounts gained were not comparable with those noted in the cases which did well. Of the 25 cases in which there was a loss, this was less than 5 lbs. in 13, 5 lbs. and over—in several a good deal over—in 12.

Then, the number of cases showing no change in weight numbered 5, or 10·8 *per cent.* of the total, as against 4·8 *per cent.* amongst the favourable cases.

The upshot, therefore, is that 67·4 *per cent.* of the cases which did not improve under this treatment lost weight or remained stationary in weight, whilst 32·6 *per cent.* gained weight.

It is to be observed, as Dr. Lewis Jones pointed out, that in electric bath treatment the patient's condition will often continue to show improvement after the baths have been left off.

I have further remarked in some cases that a second course of baths, given after an interval of a few weeks, has been attended with better results than were obtained after the first course.

The observations made upon the excretion of creatinine in certain of these cases, and which are referred to below, indicate that the baths are best given in successive short series of about ten baths each, with intervals of about a fortnight between. I am now giving the baths in such series.

It is worth noting that in many instances patients on their discharge have expressed their belief that the electric bath treatment was a factor in promoting their recovery.

As to duration of residence of those who recovered, the average was six and one-third months. In a large number of my earlier cases this period was reckoned from the date of admission; had it been calculated in all cases, as it properly was in the later ones, from the date of commencement of the baths, the period would have been shorter.

Apart from the 108 electric bath cases dealt with above, I have given in 16 cases simple warm baths at the same temperature as the electric baths, under the same conditions and in the same number. The patients were of the same class in the two series, and no distinction was of course made as to diet. And it may here be stated that no special diet was given to the patients who had these kinds of baths; special diet was served only to the series of cases to be mentioned later, in which the creatinine excretion was estimated. Of these 16 control cases 10 gained weight; below 2 lbs. in 4 cases, 2 lbs. in 3 cases and up to 6, 8 and 9 lbs. in 3 cases. That is, the gain was 5 lbs. or more in 30 *per cent.* as against 62 *per cent.* in the electric bath cases. Five lost weight up to 2 lbs. in 4 cases, 4 lbs. in 1 case, and in 1 there was no change. As regards mental improvement, 2 showed improvement, of whom 1 later recovered, and 14 showed no change. So that 12·5 *per cent.* showed improvement amongst the controls, as against 57·4 *per cent.* showing recovery or improvement amongst the electric bath cases.

It is obvious that the number of controls had to be limited.

The conclusion I have come to from my experience is that short courses of electric baths, of the kind described, constitute a useful means of treatment in cases of the kind above mentioned. They may advantageously be combined with measures such as Swedish movements and massage, though of course such combinations of treatment are not dealt with in this paper.

It is well known that a few physicians have brought about cures by suggestion in the waking state in patients on or about the borderland of sanity and insanity, and in such electricity might well act beneficially as a means of suggestion. I am, and surely all of experience must be, of the belief that the personal influence—which is really suggestion—of the physician and the nurse are of very great importance in dealing with many patients definitely insane, especially, of course, at certain periods in the malady, when they are more amenable to suggestion. I should be quite prepared to learn that in such cases electricity in the shape of faradism, electric bath, high-frequency or spark-discharges had been the means of completing cure, the applications having been accompanied with appropriate verbal suggestion. In the cases I have reported in this paper no suggestions were made. I might perhaps mention two cases, not included in the above series, in which the effects of auto- and verbal suggestion were observed; one was that of a youth in a state of stupor (at other times he was maniacal), who after the third bath suddenly improved, and later recovered. He spoke of the "pain" produced by the current as having been the means of bringing him round. The other case was that of a female, æt. 39, who was brought from another asylum unable to walk or to lift her left arm. She had been lying paralysed for six years, and was brought to us in an ambulance. As the result of one electric bath with emphatic use of suggestion she became somewhat collapsed; she was put to bed in hot blankets. On recovering, the temperature rose to 101·4° F.; she was flushed and excited, and began running up and down the dormitory. She was put to work in the laundry, and was discharged within a few weeks of admission. This result is of course strictly comparable to what is witnessed at religious shrines, and in connection with faith-healing agencies.

I had for some time been desirous of ascertaining whether any evidence could be obtained of the effects of electricity administered through the medium of a bath upon metabolism, and shortly after coming to Cardiff my friend, Mr. Mackenzie Wallis, of the Physiological Department, University College, Cardiff, now lecturer in physiological chemistry there, suggested that we should record the changes, if any, produced upon the excretion of creatinine by electric baths in some cases. As a control the changes produced by warm baths alone were noted.

We have accordingly for the last nine months made a large number of observations, a great number of which we have unfortunately had to discard, because of the failure to collect the whole of the twenty-four hours' urine, notwithstanding every care, in the insane with whom we had to deal, because of the rapid decomposition which the urine in several cases unaccountably underwent, and because of the difficulty of getting the patients to keep to a fixed diet. We have, however, succeeded in obtaining some reliable records, which it is hoped may hereafter be added to. In these cases a fixed diet was given. Our results are here communicated by Mr. Wallis.

Cases which Recovered or Improved under Electric Bath Treatment.

Class of case.	Weight-changes in connection with baths.	No. of baths.	Mental recovery or improvement, and in what time recovered.
1. Puerperal; post-maniacal confusion; much physical reduction.	Slight losses, then gains, finally gained 5 lbs.	12	Recovered in 6 mos.
2. Puerperal.	Stationary, final gain 1⅛ lbs.	9	Recovered in 4½ mos.
3. Puerperal, post-maniacal confusion.	Progressive gains, ending in gain of 9 lbs.	10	Recovered in 7½ mos.
4. Acute melancholia, much physical reduction.	Progressive gains, final gain of 9 lbs.	8	Recovered in 13 mos.
5. Acute mania.	Practically stationary till near end, when gain of 5 lbs.	15	Recovered in 11 mos.
6. Adolescent mania with exaltation; well-nourished.	Gains and losses of a few lbs., final loss of 5 lbs.	9	Improved.
7. Delusional; well-nourished.	Stationary till towards end, then gain 5 lbs.	9	Improved.
8. Melancholia; reduced.	Gain in weight; final gain, 12 lbs.	7	Recovered in 7 mos.
9. Primary dementia; reduced.	Slight gains; ultimate gains of 3 lbs.	16	Recovered in 9 mos.
10. Melancholia; well-nourished.	Loss of 3 lbs.	6	Slight improvement.
11. Mania at puberty; reduced.	First series: first losses, finally gain of 4 lbs.	12	Some improvement.
	Second series: progressive gains to final of 9⅛ lbs.	9	Much improved, discharged relieved in 5½ mos.
12. Melancholia; some dementia; reduced.	Losses; finally lost 8 lbs.	8	Improvement, recovered several months after.
13. Melancholia; very reduced.	Constant gains; final gain, 1 st. 1½ lbs.	29	Recovered in 7 mos.

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Class of case.	Weight-changes in connection with baths.	No. of baths.	Mental recovery or improvement, and in what time recovered.
14. Stupor; reduced.	Lost to 13 lbs., picked up, finally loss of 4 lbs.	22	Improvement, more marked 2½ mos. after cessation of baths.
15. Melancholia; fairly nourished.	Slight losses, final loss of 3 lbs. (in very fine condition)	10	Great improvement.
16. Melancholia; poorly nourished.	No change in weight.	8	Discharged improved in 8 mos. after baths began.
17. Acute melancholia; reduced.	Progressive gains, finally of 9 lbs.	10	Recovered 3 mos. after baths began.
18. Acute melancholia; well-nourished.	After gaining a stone, ended with gain of only 3 lbs.	29	Improved, working in ward.
19. Melancholia with stupor; thin, anæmic.	Lost, gained slightly, final loss (uncertain amount)	12	Recovered in 5 mos.
20. Acute melancholia; fairly well nourished.	Gained 3 lbs.	7	Recovered in 5 mos.
21. Fairly acute melancholia.	Gained to 3 lbs., final gain 1½ lbs.	15	Recovered in 6 mos.
22. Melancholia (subacute); reduced.	1st course: lost 5½ lbs.	9	Some improvement.
	2nd course: progressive gains, final 8 lbs.	14	Much physical improvement.
23. Delusional; fairly well nourished.	Gradual gains, to final of 6½ lbs.	13	Recovered in 4 mos.
24. Mania; reduced; anæmic.	Gains; final gain, 7½ lbs.	22	Recovered 4 mos. from admission, 3 mos. after baths started.
25. Acute melancholia; reduced physically.	Gains to 5½ lbs.; final gain, 2½ lbs.	15	Improvement; working.
26. Melancholia; thin and poor physique.	Gained 9 lbs., sunk, final gain 1½ lbs.	15	Recovered in 4 mos.
27. Mania; reduced.	Gained 6 lbs.	16	Discharged, relieved, in 9 mos.
28. Melancholia with stupor; reduced.	First course: progressive losses to final of 6 lbs.	16	No change.
	Second course (2 yrs. later): gains to final of 4½ lbs.	18	Improved, helps in work.
29. Mania: good condition.	Progressive gains; final of 5 lbs.	15	Recovered in 11 mos.
30. Melancholia; good condition.	Progressive gain; final of 4 lbs.	12	Improved, removed by friends.
31. Mania—stupor (juvenile dementia); reduced.	Gain, loss, final gain, 4 lbs.	13	Some improvement.
32. Melancholia; reduced.	Gain of 2½ lb., finally of 1 lbs.	17	Some improvement.
33. Stupor—melancholia; reduced.	Gain to first 2½ lbs., finally, 13½ lbs.	19	Recovered in 6½ mos.

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Class of case.	Weight-changes in connection with baths.	No. of baths.	Mental recovery or improvement, and in what time recovered.
34. Melancholia with stupor; reduced.	1st course: lost 7 lbs. 2nd course: lost 5 lbs.	15 19	No improvement. Some improvement. Left, recovered, 7 mos. after last bath.
35. Melancholia; good physical state.	Progressive gains to final of 12 lbs.	20	Reported brighter and working as result of baths; recovered in 9 mos.
36. Stupor; fair condition.	Gained 2 lbs.	18	Recovered in 6 mos.
37. Melancholia; reduced.	Progressive gains to final of 6½ lbs.	21	Recovered in 3 mos.
38. Melancholia; good condition.	First course: loss of 2½ lbs.	17	Improvement under baths, later relapse after cessation.
	Second course: gain of 2½ lbs.	12	Recovered in 10 mos.
39. Mania—melancholia; reduced.	Progressive gain to final of 2½ lbs.	30 in 2 courses, 14 days' interval.	Recovered in 9½ mos.
40. Mania—stupor; reduced.	Slight losses, increased finally by 7½ lbs.	20	Recovered in 6 mos.
41. Acute melancholia; well nourished.	Progressive gains to final of 6½ lbs.	18	Improved, became tidy, and began to work, but some mental enfeeblement remained
42. Melancholia, some congenital basis; reduced physically.	Progressive gains, final of 3 lbs.	15	Improvement, got to work, more orderly.
43. Melancholia, with some dementia.	Gained ½ lb. (= no change).	15	Improved.
44. Confusional state; reduced physically.	Progressive gains to final of 5 lbs.	First course 20, second course 18, 1 mo. between.	Improved, brighter, more rational and amenable, does some work.
45. Stupor—melancholia.	First course: progressive gains to final of 3½ lbs. Second course: at close gained 11½ lbs. on original weight.	20 13	Improved, started work, discharged relieved in 11 mos.
46. Melancholia; much reduced.	Progressive gains to final of 5 lbs.	14	Slight improvement.
47. Melancholia with stupor; reduced physically.	First, loss, 1½ lbs., finally gained 5½ lbs.	14	Considerable improvement, brighter, started working. Later relapsed, and died (2 yrs.) of phthisis.

Class of case.	Weight-changes in connection with baths.	No. of baths.	Mental recovery or improvement, and in what time recovered.
48. Melancholia; reduced.	Losses to final of 10 lbs.	20	Some improvement, went out working.
49. Melancholia; reduced.	Gained 4 lbs.	20	Recovered.
50. Melancholia; fairly well nourished.	Gained 8½ lbs.	20	Recovered.
51. Melancholia; reduced.	Gained 6½ lbs.	14	Improved.
52. Hallucinatory insanity (insane conduct); well nourished (too stout).	Lost 3 lbs.	18	Improved, working, sane conduct.
53. Delusional; reduced.	Gains to final of 10 lbs.	18	Recovered in 3¾ mos.
54. Some dementia; mild delusions; reduced.	Gains to final of 7½ lbs.	20	Improved; employed.
55. Melancholia; reduced.	Early losses, final gain of 10 lbs.	18	Recovered in 2¾ mos.
56. Hypochondriacal melancholia; reduced.	Progressive gains to final of 4½ lbs.	18	Improvement.
57. Melancholia; reduced.	Progressive gains to final of 10½ lbs.	18	Recovered in 3 mos.
58. Subacute mania; fairly nourished.	Progressive gains to final of 4 lbs.	18	Improved.
59. Acute hallucinations and delusions; reduced.	Gained 6½ lbs.	14	Recovered in 3½ mos.
60. Acute melancholia; reduced.	Gained 2 lbs.	10	Improved.
61. Acute confusional state; reduced.	Gained 5 lbs.	15	Improved.
62. Stupor; reduced.	No change.	12	Improved.

Cases not Improved under Electric Bath Treatment.

Class of case.	Weight-changes in connection with baths.	No. of baths.
(*a*) Acute mania apparently passing into dementia; condition fair.	Progressive gains to final of 5½ lbs.	11
(*b*) Delusional insanity of slow growth; nutrition fair.	Limited gains and losses; final loss of 3 lbs.	14
(*c*) Stupor; reduced.	Slight losses and gains; ended same weight.	16

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Class of case.	Weight-changes in connection with baths.	No. of baths.
(*d*) Delusional; well-nourished.	Variations; ultimate loss of 2 lbs.	9
(*e*) Stupor; reduced.	Variations; final loss of 3 lbs.	8
(*f*) Melancholia; well-nourished.	Losses; final loss 3 lbs.	9
(*g*) Melancholia, with persecutory ideas; well-nourished.	Gains, but finally only 1 lbs. No change.	6
(*h*) Stupor; marked heredity.	Lost 12 lbs., and finally "considerable loss."	8
(*i*) Melancholia with stupor; reduced.	Losses, final loss 12 lbs.	26
(*j*) Melancholia; well-nourished.	Progressive gains; final of 7 lbs.	14
(*k*) Recent dementia: well-nourished.	Gained 5 lbs.	8
(*l*) Confusional state on congenital defect.	Losses, ending with final loss of 2 lbs.	12
(*m*) Subacute mania; well-nourished.	Final gain of 2 lbs.	10
(*n*) Acute melancholia; poorly nourished.	No change.	15
(*o*) Acute melancholia; thin, cyanosed.	Gained 8 lbs., then lost, final loss of 3 lbs.	18
(*p*) Acute melancholia; thin.	Gradual losses; final loss of 5 lbs.	15
(*q*) Acute melancholia; thin, cyanosed.	Losses, to final loss of 9 lbs.	15
(*r*) Acute melancholia; spare, anæmic.	Gained 9 lbs.; final gain, 5 lbs.	14
(*s*) Not stated.	No change.	22
(*t*) Stupor; well-nourished.	Losses, to final loss of 6 lbs.	37
(*u*) Melancholia; physically not stated.	Final loss of 2 lbs.	14
(*v*) Delusional; well-nourished.	Gains, final of 7 lbs.	16
(*w*) Melancholia; fair condition.	1st course: gained 8½ lbs.	14
	2nd course: gained 4½ lbs.	16
(*x*) Acute mania; good condition.	Losses, final loss of 2 lbs.	14
(*y*) Melancholia; good condition.	Losses, final loss of 1½ lbs.	14
(*z*) Stupor; good condition.	Losses; final loss of 6½ lbs.	11
(*a* 1) Melancholia; physically not stated.	Losses, final 6 lbs.	14
(*b* 1) Melancholia; reduced.	Lost 1½ lbs.	18
(*c* 1) Melancholia; reduced.	Losses, slight rise, final loss 7 lbs.	15
(*d* 1) Melancholia; reduced.	Losses, slight rise, final loss 7 lbs.	15
(*e* 1) Melancholia; spare, sallow.	Gains, to final gain of 6 lbs.	15
(*f* 1) Melancholia; good condition.	Losses, final loss 2 lbs.	13
(*g* 1) Melancholia; reduced.	Slight gain, final loss of 5 lbs.	20
(*h* 1) Subacute mania on imbecility; good condition.	Lost 3 lbs.	20
(*i* 1) Melancholia; reduced.	Gained 3½ lbs., final weight same.	13
(*j* 1) Melancholia; reduced.	Gained 4 lbs., progressively.	14
(*k* 1) Mania-melancholia; somewhat reduced.	Progressive gains, final 5 lbs.	39
(*l* 1) Melancholia; reduced.	Gained 5 lbs., finally lost 9 lbs.	19
(*m* 1) Stupor-melancholia; fairly good condition.	Gained 6 lbs.	20
(*n* 1) Stupor-melancholia; much reduced.	Gained 2 lbs.	15
(*o* 1) Juvenile dementia; much reduced.	Progressive losses, to final of 1st. 7 lbs.	18

Class of case.	Weight-changes in connection with baths.	No. of baths.
(*p* 1) Juvenile dementia; good condition.	Gained to 4 lbs., final gain 2 lbs.	21
(*q* 1) Juvenile dementia; fairly good condition.	Gained to final gain of 2 lbs.	18
(*r* 1) Some dementia, with delusions (an adolescent), reduced.	Losses to final of 5 lbs.	18
(*s* 1) Mild melancholia; well-nourished.	Progressive losses to final of 6 lbs.	18
(*t* 1) Melancholia; fairly well-nourished.	Gained 3 lbs.	19

II.—By R. L. Mackenzie Wallis.

Introduction.

The great progress in recent years of electro- and hydro-therapeutics is well known, and so far the value of this treatment has rested mainly on clinical evidence. It is of interest, therefore, if some confirmatory observations are forthcoming from the study of metabolism, since they may add a further argument in favour of the two forms of treatment. The study of metabolism in the insane is, however, encompassed by many difficulties, especially the variations that occur, and the difficulty of establishing any definite laws for one form of insanity. The lack of exact data may possibly account for this. Our present knowledge of metabolism in the insane is due to Folin and his co-workers in America, and Hoogenhuyze and Verploegh, and also Kauffmann, in Europe. Having in view the valuable contributions of these workers, it seemed advisable to select one product of metabolism which not only showed the least variation, but at the same time would demonstrate any marked changes which were taking place. The substance which most closely approximated to these conditions was creatinine, and in consequence it was selected for the present investigation. Owing to the discovery by Folin of a very rapid, and at the same time, accurate method of estimating creatinine, its significance has received unusual attention during the past few years. The results of a preliminary investigation of the effects of the two forms of bath-treatment are given below, and seem to sustain the claims made

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by other observers for this body, and justify its use in the present research.

Historical.

Previous to the work of Folin (2) on this subject, and the introduction of his method of estimation, creatinine was estimated by the Neubauer-Salkowski method (1). This method consisted in forming a zinc chloride compound and estimating the creatinine as such.

Van Hoogenhuyze and Verploegh (8) subjected this method to a critical investigation, and strongly advocated the colorimetric method of Folin (2). Subsequent workers on this subject have all recommended the latter method, and employed it in their investigations.

The absence of a really reliable method for estimating creatinine possibly accounts for the discordant results of the earlier workers.

Folin (5) came to the following conclusions: (*a*) The amount of creatinine in the urine is independent of the amount of protein in the food, or the total nitrogen in the urine. (*b*) The amount of creatinine excreted is a constant quantity for each individual. (*c*) Creatin is not present in normal urine, and occurs only in minimal quantities after injection of this substance. As a result of these observations Folin (6) devised a new theory of metabolism, and assumed that the creatinine in the urine is a product of endogenous metabolism.

The conclusions of Folin were later confirmed by Hoogenhuyze and Verploegh (8), Klercker (10), Closson (9), and Shaffer (25); the latter, however, was not inclined to entirely accept the view as to the endogenous origin of creatinine.

Since creatinine in the urine is supposed to be directly connected with creatin in the muscles, it was thought that muscular activity might influence the excretion of this substance. Folin admitted this possibility, but Hoogenhuyze and Verploegh have clearly demonstrated that muscular work has no influence on the excretion of creatinine, provided the diet is sufficient.

If, however, the diet is insufficient, as, for example, in starvation, then the output of creatinine is increased, the material for contraction in this case being drawn directly from the muscle proteins. Shaffer (25) has obtained similar results.

Creatinine is therefore not produced as a result of energy changes within the muscle.

With regard to the factors which regulate the excretion of this body in normal individuals, Folin stated that the chief factor was the body-weight. This relationship has also been specially emphasised by Closson, Shaffer, and Benedict and Myers (11).

The ratio of creatinine excreted to the body-weight has been termed the "creatinine co-efficient," and is adopted in the following observations. The physical condition has also to be taken into account when investigating creatinine metabolism, since corpulent persons yield less creatinine than lean ones. On this observation is based the view that the creatinine excretion is proportional to the active mass of protoplasmic tissue.

Benedict and Myers (11), working on the creatinine excretion in women, showed that it was much lower than in men. The large amount of subcutaneous fat in women may possibly account for the low values obtained, as sex by itself has probably no influence.

Age appears to play a part in the output of this body, since elderly people excrete less creatinine than young people of the same body-weight.

The remarkable uniformity in the elimination of creatinine and its constancy from day to day enables us to obtain values for the normal individual. The "creatinine co-efficient," or in other words, the ratio of creatinine excreted per kilo. of body-weight, varies from 20 mgrm. per kilo. in corpulent men to 25 mgrm. in lean men. The normal limits seem to lie between 18 and 30 mgrm. per kilo. of body-weight (Folin).

The existence of other factors in regulating the creatinine output in man has been demonstrated by work on pathological subjects. The work may be summarised under three headings:

(1) Cases in which cellular activity of high intensity has been involved, such, for example, as maniacal conditions, fever, acromegaly, and exopthalmic goitre.

(2) Cases in which cellular activity is depressed, as in paralysis, fasting, and leukæmia.

(3) Cases presenting deficiencies in the functions of individual organs, especially the liver and kidney.

Considering the conditions presented in Group (1), a rise in creatinine excretion has been demonstrated by Hoogenhuyze

and Verploegh (12) under maniacal conditions and also under alcohol. Benedict and Myers (11), on the other hand, found no influence in mania. The effects of fever on the excretion of creatinine was studied by Leathes (17), who showed that the creatinine output was increased. With the disappearance of the fever the creatinine falls below normal. Similar observations have been made by Hoogenhuyze and Verploegh, and also Shaffer. Shaffer and also Froschbach (22) noted a low output in exophthalmic goitre, where the tissue katabolism may be much increased.

With regard to the conditions enumerated in the second group, a diminished output has been observed during fasting by Hoogenhuyze and Verploegh (8), Benedict (14), and Benedict and Diefendorf (15), in lymphatic leukæmia by Shaffer, and in muscular dystrophy by Spriggs (16) (half normal), and after administration of potassium bromide, Hoogenhuyze and Verploegh. Muscular rest, on the other hand, according to Shaffer, produces no change in creatinine excretion.

The influence of individual organs has been demonstrated by Mellanby (23) in the case of the liver, where a low excretion of creatinine characterises disease of that organ. Hoogenhuyze and Verploegh (12) find, besides a low output, a normal, and sometimes a high creatinine content as a result of hepatic disease. Several observers, notably Underhill and Kleiner (19), Richards and Wallace (20), Leffmann (21), and Lusk (18), have induced disease in the liver, and find a gradual fall in the amount of creatinine eliminated.

The elimination of creatinine in the insane has been investigated by Folin, in collaboration with Shaffer and Hill (3), by Benedict and Myers (11), and by Hoogenhuyze and Verploegh (12). These observers find that in accordance with other pathological conditions the output of creatinine is generally below normal. Folin concludes from his metabolism studies on over twenty cases "that mental disorders do not necessarily involve great changes in metabolism sufficient to modify the creatinine output." The creatinine excretion also bears no definite relation to the form of insanity.

Method of Estimation.

Throughout this investigation the colorimetric method devised by Folin in 1904 has been used. The method is based on the colour reaction given by creatinine with picric acid in an alkaline solution. The coloration so produced is compared with a half normal solution of potassium bichromate in a Duboscq colorimeter. In general, 15 c.c. of a saturated solution of picric acid and 5 c.c. of a 10 *per cent.* solution of caustic soda were added to 10 c.c. of urine in a 500 c.c. volumetric flask. The volume of urine used had frequently to be varied to ensure more accurate readings. This mixture was allowed to stand for at least five minutes, all due precautions being taken to maintain a constant temperature throughout. The contents of the flask were then diluted up to the 500 c.c. mark, and several readings taken immediately. Generally three persons made separate observations, and the results were compared. At the beginning of this research a number of estimations of creatin were made by Folin's method. The results obtained were in all cases extremely low, and in many cases negative. Consequently it did not seem advantageous to continue the estimation of this substance. The samples of urine were periodically tested for sugar and albumen. The reaction, volume, specific gravity, and general appearance, *i.e.*, whether clear or turbid, were carefully recorded daily, and these data are included in the tables below. The deposit on several occasions was microscopically examined, and revealed numerous crystals of calcium phosphate and oxalate. Chloroform was used as a preservative, and soon found to be unsatisfactory, the creatinine disappearing very rapidly. The great proneness to decomposition is a very marked feature of the urine of the insane, and it appears to be due to bacterial contamination. This contamination I am inclined to think takes place in the patient's own body, since the urine as voided was covered with a cloth and brought to the laboratory to be collected in large, clean, Winchester quart-bottles. The reaction of the urine did not seem to affect the estimation of creatinine. Owing to this ready decomposition, and with it a disappearance of the creatinine, it was thought advisable to estimate the creatinine as early as possible after the twenty-four hours' sample had been collected. In this way fairly concordant results were

obtained. After the estimation the samples were made faintly acid with acetic acid, and placed in a steam steriliser. They were then sent by road to the Physiological Laboratory, Cardiff (about four miles away) for a confirmatory reading. In many cases I was unable to strike a colour with the picric acid and alkali, and the colour when present gave a tint corresponding to just half the amount of creatinine recorded a few hours before.

For example:

	Non-sterilised sample.	Sterilised sample.
1 .	20 c.c. urine = 6 mm. .	20 c.c. = 15·3 mm.
2 .	10 ,, = 8·6 mm. .	10 ,, = 13·0 mm.
3 .	20 ,, = 5·9 mm. .	20 ,, = 14·5 mm.

It was noted at the same time that on adding the alkali a mass of yellowish needle-like crystals were deposited, which only slowly dissolved in water. Now these sterilised samples have in many cases kept quite fresh for months after collection. An explanation is therefore required to account for this change, and at present only a provisional one can be given.

One patient whose urine was examined for creatinine did not show any creatinine at all, even with a volume of 25 c.c. The marked feature of this urine was the enormous deposit of phosphates which settled out daily.

Now the samples which gave the above results after sterilisation were all characterised by the same excess of earthy phosphates. It was consequently thought possible that the phosphates prevented the alkali or the picric acid from reacting with the creatinine, and to avoid this larger quantities of these substances were taken, but without effect. The phosphates present, if they act at all, must therefore exert their influence on creatinine itself. As to the nature of this influence, I am not at present able to state, but the subject is under investigation. Possibly the yellowish needles may represent a creatinine phosphate combination, since after removal of the phosphates this precipitate does not occur.

4. *Dietary and Treatment.*

At the commencement of the experiments a creatin-free diet was adopted, and the patients kept in bed. In view of these somewhat unsatisfactory conditions, and taking into

account the previous work upon the subject, it did not seem necessary to continue this treatment This decision was further favoured by the results of a metabolism experiment carried out by the writer upon himself. The results were as follows:

M. W—, weight 62·5 kilos. Diet: Creatin-free, consisting of eggs, milk, cheese, bread, butter, and water.

Commenced on Sunday evening.

Monday–Tuesday	.	vol. 1030 c.c.	.	Creatinine	1·30 grm.
Tuesday–Wednesday		,, 1100 ,,	.	,,	1·31 ,,
Wednesday–Thursday		,, 1050 ,,	.	,,	1·35 ,,
Thursday–Friday	.	,, 1140 ,,	.	,,	1·36 ,,
Friday–Saturday	.	,, 1040 ,,	.	,,	1·36 ,,

Exercise was taken each day, and a long walk of about twenty miles on the Wednesday afternoon. The creatinine excretion on an ordinary diet gave an average value of 1·40 grm. The creatinine co-efficient during the experimental diet period was about 22·7 mgrm.

From the above observations it will be seen that the diet has very little if any influence on the excretion of creatinine, and similarly the effects of muscular exercise.

The results with the patients are, fortunately, similarly unaffected by the change of diet. The diet was the usual hospital diet, but in some cases extra diet was given, such as eggs, milk, and cheese. Complete records have been kept of the exact amount of food given and the amounts taken at each meal.

The treatment adopted was of two forms: electric baths and warm baths at 100° F.

The temperature of all the patients under observation was quite normal and practically unaffected by the treatment.

The patients receiving electric baths improved both mentally and physically, whilst those having warm baths did not show the same improvement.

These observations have been fully described by Dr. Goodall, and it now remains to demonstrate the effects, if any, on the elimination of creatinin.

Table I.

Electric baths.—A. Le G—, female, æt. 28. Melancholia with

stupor. Weight on commencing baths, 50·5 kg.; weight on finishing baths, 50·2 kg. Height, 1·62 metres.

Diet.—Breakfast: Bread, 170·04 grm.; margarine, 14·17 grm.; coffee, 0·568 lit. *Dinner:* Bread, 56·68 grm.; meat, 170·04 grm; peas, 141·70 grm., or potatoes, 453·44 grm. *Tea:* Bread, 170·04 grm.; margarine, 14·12 grm.; tea, 0·568, lit.

Twenty-four hours' sample.

1909.	Vol.	Sp. gr.	Creatinine.	Creatinine per kilo.	Water.	Remarks.
May 10	2020	1015	1·143	—	—	Preliminary observations, creatin-free diet.
,, 11	1480	1010	0·768	—	—	
,, 12	1540	1010	1·084	14 mgrm.	—	
,, 13	1290	1015	0·842	—	—	
,, 14	1150	1015	0·802	—	—	
,, 15	1070	1020	0·709	—	—	
,, 19	1110	1025	1·354	—	0·852 lit.	Electric bath.
,, 20	855	1015	1·330	—	1·420 ,,	,,
,, 21	1220	1015	1·039	23 mgrm.	1·420 ,,	,,
,, 22	1300	1015	0·915	—	1·420 ,,	,,
,, 23	1227	1012	—	—	1·420 ,,	,,
,, 24	1125	1015	1·40	—	1·420 ,,	Last bath.
,, 25	950	1020	0·884	—	1·420 ,,	—
,, 26	930	1020	0·865	17 mgrm.	1·420 ,,	—
,, 27	1140	1015	0·847	—	1·420 ,,	—

A. le G—. Melancholia with stupor. The effects of the electric bath treatment on this patient are well shown in the table. The maximum figure recorded was on May 24th and the minimum on May 15th. The co-efficient in this case is practically normal.

Table II.

Electric baths.—M. A. T—, female, æt. 37. Acute melancholia. Weight on commencing baths, 54·6 kg.; weight on finishing baths, 55·5 kg. Height 1·67 metres.

Diet.—Breakfast: Bread, margarine, coffee. *Dinner:* Meat, fish (alternate weeks), bacon, vegetables. *Tea:* Bread, margarine. *Daily extras:* Milk, eggs, milk puddings.

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Twenty-four hours' sample.

1909.	Vol.	Sp. gr.	Reaction.	Appearance.	Creatinine.	Creatinine per kilo.	Remarks.
Nov. 23	1040	1020	Acid	—	0·645	—	—
„ 24	960	1020	„	—	0·537	11·7 mgrm.	—
„ 25	1140	1020	„	—	0·752	—	Bath.
„ 26	1100	1020	„	—	0·855	14 mgrm.	„
„ 27	820	1020	„	—	0·697 ?	—	„
„ 28	1345	1020	„	—	0·897	—	„
„ 29	820	1020	„	—	0·885	15·6 mgrm.	„
„ 30	1100	1020	„	—	0·862	—	„
Dec. 1	1410	1015	„	—	0·662	—	„
„ 2	1320	1020	„	—	0·712	11·7 mgrm.	„
„ 3	1100	1020	„	—	0·550	—	„
„ 4	1185	1015	Neutral	—	0·379 }	12·8 mgrm.	Last bath.
„ 5	1230	1017	Acid	Turbid	1·114 }		—
„ 6	1400	1016	„	Very turbid	0·644	—	—
„ 7	1550	1015	„	Turbid	0·66	—	—
„ 8	1120	1015	Alkaline	„	0·425	—	—

M. A. T—. Compare Table II*a*.

TABLE II*a*.

Twenty-four hours' sample.

1909.	Vol.	Sp. gr.	Reaction.	Appearance.	Creatinine.	Creatinine per kilo.	Remarks.
Dec. 28	1330	1015	Neutral	+	0·611	—	—
„ 29	750	1025	Acid	—	0·612	11·1 mgrm.	—
„ 30	800	1025	„	—	0·712	—	Electric bath.
„ 31	Missed		—	—	—	—	„
1910							
Jan. 1	1500	1015	Acid	—	0·675	—	„
„ 2	2040	1009	„	—	0·693	11·1 mgrm.	„
„ 3	1720	1010	„	—	0·722	—	„
„ 4	860	1015	„	—	0·498	—	„
„ 5	1440	1008	„	—	0·432	12·3 mgrm.	„
„ 6	2020	1010	„	—	0·747	—	„
„ 7	2710	1006	„	—	0·813	—	Last bath.
„ 8	1900	1015	„	—	0·874	—	—
„ 9	2080	1010	„	—	0·728	12·4 mgrm.	—
„ 10	1570	1010	„	—	0·785	—	—
„ 11	1710	1010	„	—	0·615	—	—
„ 12	1840	1012	„	—	0·754	—	—
„ 13	1720	1015	„	—	0·752	—	Electric bath.
„ 14	2470	1010	„	—	0·889	13·1 mgrm.	„
„ 15	1530	1015	„	—	0·765	—	„
„ 16	1744	1010	„	—	0·643	—	„
„ 17	1270	1015	„	—	0·726	—	Last bath.
„ 18	1700	1010	„	—	0·629	—	—
„ 19	2170	1015	„	—	0·868	12·6 mgrm.	—
„ 20	2150	1010	„	—	0·718	—	—
„ 21	1370	1015	„	—	0·609	—	—
„ 22	Missed		—	—	—	—	—

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Electric baths.—Second series. M. A. T—, female, æt. 37. Acute melancholia. Weight on commencing baths, 58 kg.; weight on ceasing baths, 58·1 kg. Height 1·67 metres.

Diet.—Same as before. *Daily extras:* Milk, eggs, milk puddings.

M. A. T—. Acute melancholia with suicidal tendencies. In addition to the ordinary diet the patient received two pints of milk, one egg, and milk puddings daily.

The effects of a series of electric baths of short duration are well illustrated in this table. It will be noted that there is a gradual increase in the creatinine excretion, which appears to continue after the baths have ceased. The volume of urine was considerable, and on most days 20 c.cm. had to be taken to ensure a reading with the colorimeter.

Table III.

Electric baths.—October 17th to November 1st, 1909. R. R—female, æt. 27. Acute hallucinations, delusions, secondary

Twenty-four hours' sample.

1909.	Vol.	Sp. gr.	Reaction.	Appearance.	Creatinine.	Creatinine per kilo.	Remarks.
Oct. 15	880	1017	Acid	—	0·519	—	—
,, 16	1830	1010	,,	—	0·704	13·1 mgrm.	—
,, 17	650	1010	Neutral	—	0·475	—	Electric bath.
,, 18	—	—	—	—	—	—	—
,, 19	1120	1015	Acid	—	0·705	—	—
,, 20	1218	1013	,,	—	0·666	15·8 mgrm.	—
,, 21	1320	1010	,,	—	0·673	—	—
,, 22	1000	1015	,,	—	0·575	—	—
,, 23	1340	1010	Alkaline	+	0·616	—	—
,, 24	1240	1010	,,	+	0·539	13·4 mgrm.	—
,, 25	1710	1015	,,	+	0·910	—	—
,, 26	Missed		—	—	—	—	—
,, 27	1270	1015	Neutral	+	0·750	—	—
,, 28	760	1015	,,	+	0·647	17·1 mgrm.	—
,, 29	1440	1017	Acid	+	0·806	—	—
,, 30	610	1015	,,	—	0·202	—	—
,, 31	1515	1015	,,	+	0·421	—	—
Nov. 1	620	1015	Neutral	+	0·339	—	Last bath.
,, 2	1650	1015	Acid	—	0·841	—	—
,, 3	840	1025	Neutral	+	0·823	16·6 mgrm.	—
,, 4	620	1025	Acid	—	0·626	—	—
,, 5	790	1025	Neutral	+	0·633	—	—

depression. Weight on commencing baths, 42·9 kg.; weight on ceasing, 45·9 kg. Height 1·54 metres.

Diet.—Ordinary female diet.

The amount of the various constituents of the diet as in Table I.

R. R—. Took food well, and increased in weight as a result of treatment, *viz.*, 3 kg. This increase in weight is mainly due to a deposition of subcutaneous fat, as may be judged from the height of the patient and general appearance. The electric baths were suspended on the 18th and 19th. The maximum figure occurred during the baths, *viz.*, 0·910 grammes, and also the lowest figure, 0·202 grammes. This latter value is possibly due to an error in collection of the twenty-four hours' sample.

Table IV.

Electric baths.—D. H—, female, æt. 25. Melancholia with stupor. Weight 49 kg. Weight on commencing baths, 48·4 kg.; weight on finishing baths, 49·3 kg. Height 1·67 metres.

Diet.—Breakfast: Bread, 170·04 grm.; margarine, 14·17 grm.; coffee, 0·508 lit. *Dinner:* Bread, 56·68 grm.; meat and bacon, 170·04 grm.; vegetables, peas, 141·70 grm., or potatoes, 453·44 grm.; water, 0·568 lit. *Tea:* Bread, 170·04 grm.; margarine, 14·17 grm.; tea, 0·568 lit.

Twenty-four hours' sample.

1909.	Vol.	Sp. gr.	Total creatinine.	Creatinine per kilo.	Water consumed.	Remarks.
May 18	—	—	—	—	0·852 lit.	—
„ 19	890	1015	0·667	—	1·704 „	—
„ 20	1180	1015	0 884	—	—	—
„ 21	1700	1015	1·105	16 mgrm.	1·704 lit.	—
„ 22	750	1015	0·532	—	1·420 „	—
„ 23	1140	1018	0·941	—	1·420 „	—
„ 24	1100	1020	0·679	—	1·420 „	Bath.
„ 25	1270	1015	0·842	—	1·704 „	„
„ 26	1100	1025	0·947	16 mgrm.	1·420 „	„
„ 27	840	1025	0·756	—	1·420 „	„
„ 28	1980	1015	0·950	—	1·420 „	„
„ 29	1700	1015	0·688	—	1·420 „	„
„ 30	1410	1016	0·465	—	1·420 „	Last bath.
„ 31	1400	1018	—	—	1·420 „	—
June 1	1140	1020	0·684	14 mgrm.	1·420 „	—
„ 2	1720	1015	0·610	—	1·704 „	—
„ 3	1120	1020	0·772	—	—	—

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D. H—. Melancholia with stupor. The patient took her food well, but did not show the same changes in creatinine output as A. Le G. (Table I). The daily excretion of creatinine during the electric bath period was only very slightly increased.

Table V.

Electric baths.—C. G. H—, male, æt. 29. Acute melancholia. Weight, 50·2 kg.; weight on commencing baths, 49·3 kg.; weight on finishing baths, 49·3 kg. Height, 1·67 metres.

Diet.—Breakfast: Bread, 226·72 grm.; margarine, 14·17 grm.; coffee, 0·568 lit. *Dinner:* Bread, 56·68 grm.; meat, 198·38 grm.; peas, 141·70 grm., or potatoes, 453·44 grm.; water, 0·568 lit. *Tea:* Bread, 226·72 grm.; margarine, 24·17 grm.; tea, 0·568 lit.

Twenty-four hours' sample.

1909.	Vol.	Sp. gr.	Creatinine.	Creatinine per kilo.	Water.	Remarks.
May 10	720	1025	0·806	—	—	Preliminary observations on a creatin-free diet.
„ 11	1070	1015	0·832	17 mgrm.	—	
„ 12	550	1030	0·839	—	—	
„ 13	750	1030	0·945	—	—	
„ 14	1470	1015	0·654	—	—	
„ 15	950	1020	0·665	—	—	
„ 19	750	1020	0·945	—	1·136 lit.	Electric bath.
„ 20	900	1020	0·758	21 mgrm.	1·136 „	„
„ 21	820	1025	1·418	—	1·136 „	„
„ 22	1180	1020	1·123	—	1·420 „	„
„ 23	980	1021	0·770	—	1·704 „	„
„ 24	1170	1020	0·939	—	1·278 „	Last bath.
„ 25	940	1025	—	—	1·420 „	—
„ 26	840	1025	0·829	—	0·994 „	—
„ 27	1620	1015	0·830	18 mgrm.	1·278 „	—
„ 28	1220	1020	0·978	—	1·136 „	—

C. G. H—. This patient took his food very well, and showed mental improvement as a result of the treatment. The increased excretion of creatinine on May 21st and 22nd is very striking.

Table VI.

Electric baths.—J. O'B—, male, æt. 24. Weight, 60·3 kg.;

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weight on commencing baths, 58 kg.; weight on finishing baths, 58·2 kg. Height, 1·67 metres.

Diet.—Breakfast: Bread, 226·72 grm.; margarine, 14·17 grm.; coffee, 0·568 lit. *Dinner:* Bread, 56·68 grm.; meat, 170·04 grm.; potatoes, 453·44 grm., or peas, 141·70 grm.; water, 0·568 lit. *Tea:* Bread, 226·72 grm.; margarine, 14·17 grm.; tea, 0·568 lit.

Twenty-four hours' sample.

1909.	Vol.	Sp. gr.	Creatinine.	Creatinine per kilo.	Water.	Remarks.
July 24	2940	1015	1·440	—	1·420 lit.	—
„ 25	1055	1023	1·392	21·3 mgrm.	1·420 „	—
„ 26	990	1020	0·881	—	1·420 „	—
„ 27	1380	1020	1·324	—	1·420 „	—
„ 28	1800	1015	1·602	22·9 mgrm.	1·420 „	—
„ 29	1170	1015	1·067	—	1·420 „	—
„ 30	1020	1015	0·979	—	1·420 „	—
„ 31	1150	1025	1·449	21·1 mgrm.	1·420 „	—
Aug. 1	1250	1018	1·250	—	1·420 „	—
„ 2	1810	1010	0·932	—	1·420 „	—
„ 3	1090	1015	0·773	17·0 mgrm.	1·420 „	Bath.
„ 4	890	1027	1·041	—	1·420 „	„
„ 5	1650	1020	1·161	—	1·420 „	„
„ 6	960	1020	1·094	15·8 mgrm.	1·704 „	„
„ 7	870	1017	1·668	—	1·704 „	„
„ 8	1665	1018		—	1·704 „	„
„ 9	970	1020	1·218	—	—	—

J. O'B—. Juvenile dementia; partial stupor. This patient took his food well, and showed mental improvement. The creatinine excretion in this patient was normal, but during the baths it showed a slight decrease. The estimations were made during a period when the temperature was quite high, the laboratory temperature being 23° C. This table is inserted to show the difficulties which are encountered and the great proneness of the urine to bacterial decomposition. An interesting observation in connection with this patient was the sudden appearance of appreciable quantities of indican in the urine on August 4th, which increased in amount on the 5th and 6th. On August 9th and 10th it was quite absent, and a similar test applied at the end of the month was also negative.

Table VII.

Electric baths (from October 14th to November 1st, 1909.—J. L—, male, æt. 39. Melancholia, based on delusions of throat disease. Weight before commencing baths, 54·8 kg.; weight on commencing baths, 50·2 kg.; weight on finishing baths, 50·8 kg. Height, 1·62 metres.

Diet.—Breakfast: Bread, 226·72 grm.; margarine, 14·17 grm.; coffee, 0.568 lit. *Dinner:* Bread, 56·68 grm.; meat, 170·04 grm.; potatoes, 453·44 grm., or peas, 141·70 grm., water, 0·568 lit. *Tea:* Bread, 226·72 grm.; margarine, 14·17 grm.; tea, 0·568 lit.

Twenty-four hours' sample.

1909.	Vol.	Sp. gr.	Reaction.	Appearance.	Creatinine.	Creatinine per kilo.	Water.
Oct. 12	850	1020	Acid	+	0·467	—	1·704 lit.
,, 13	690	1020	,,	—	0·772	12 mgrm.	1·136 ,,
,, 14	790	1025	,,	—	0·481	—	1·136 ,,
,, 15	750	1020	,,	—	0·585	—	1·704 ,,
,, 16	1140	1020	,,	—	0·855	—	1·704 ,,
,, 17	840	1015	,,	+	0·915	—	1·704 ,,
,, 18	—	—	—	—	—	—	—
,, 19	800	1025	Acid	+	0·920	—	1·704 ,,
,, 20	740	1025	,,	+	0·806	—	1·704 ,,
,, 21	650	1025	,,	+	0·780	17 mgrm.	1·136 ,,
,, 22	850	1020	,,	+	0·926	—	1·704 ,,
,, 23	600	1025	,,	+	0·702	—	1·704 ,,
,, 24	470	1026	,,	+	0·653	—	1·136 ,,
,, 25	550	1030	Alkaline	+	0·753	—	1·136 ,,
,, 26	550	1030	Acid	+	0·753	—	1·136 ,,
,, 27	370?	1030	,,	+	—	—	1·136 ,,
,, 28	420?	1025	,,	+	0·453	—	0·568 ,,
,, 29	840	1020	,,	+	0·856	—	1·420 ,,
,, 30	440	1025	,,	+	0·444	—	1·136 ,,
,, 31	410	1030	,,	+	0·618	—	1·704 ,,
Nov. 1	540	1025	,,	+	0·615	—	1·704 ,,
,, 2	330	1025	,,	+	0·547	—	1·136 ,,
,, 3	440	1030	,,	+	0·646	12·4 mgrm.	1·704 ,,
,, 4	460	1027	Neutral	+	0·676	—	1·704 ,,
,, 5	500	1030	Alkaline	+	0·665	—	0·568 ,,
,, 6	—	—	—	—	—	—	0·568 ,,

J. L—. Melancholia. The patient took his food well, and at different periods received both electric and warm baths. A comparison of the tables reveals the effects of the two forms of treatment. The table also demonstrates the gradual decrease in the amount of creatinine excreted when the electric baths extend over a long period.

Table VIII.

Warm baths, 100° F.; May 19th–25th.—E. M—, female, æt. 24. Acute mania. Weight on commencing baths, 53·4 kg.; weight on ceasing baths, 52·1 kg. Height, 1·60 metres.

Diet.—Breakfast: Bread, margarine, tea. *Dinner*: Bread, meat, vegetables. *Tea*: Bread, margarine, tea. Ordinary female diet. Patient took food well.

Twenty-four hours' sample.

1909.	Vol.	Sp. gr.	Creatinine.	Creatinine per kilo.	Water.	Remarks.
May 10	920	1025	0·737	—	—	Preliminary observations.
,, 11	520	1025	0·676	15 mgrm.	—	
,, 13	790	1020	0·995	—	—	—
,, 16	860	1015	0·662	—	1·420 lit.	—
,, 19	1000	1020	1·125	—	1·420 ,,	Warm bath.
,, 20	990	1025	1·248	19 mgrm.	1·420 ,,	,,
,, 21	840	1020	0·819	—	1·420 ,,	,,
,, 22	—	—	—	—	1·420 ,,	,,
,, 23	1330	1015	0·755	—	1·420 ,,	,,
,, 24	850	1020	0·688	—	1·420 ,,	,,
,, 25	690	1025	0·833	—	1·420 ,,	Last bath.
,, 26	530	1025	0·734	16 mgrm.	1·704 ,,	—
,, 27	1270	1017	0·749	—	1·420 ,,	—

E. M—. Acute mania. Patient took food well. (Amounts of constituents as in Table I). It will be noted that the excretion of urine does not correspond with the volume of actual fluid consumed daily. The excretion of creatinine was increased as a result of the warm bath treatment, but the effects were only temporary. This sharp rise is in accordance with the observations of Hoogenhuyze and Verploegh (patient No. 12). In all probability the baths when first given gave rise to considerable mental excitement, and this may possibly account for the increased excretion.

Table IX.

Warm baths, 100° F.—M. E. W—, female, æt. 28. Adolescent dementia. Weight on commencing baths, 45·9 kg.; weight on ceasing baths, 46·3 kg. Height, 1·65 metres.

Diet.—Ordinary female diet. (Amounts of constituents as in Table I.)

Twenty-four hours' sample.

1909.	Vol.	Sp. gr.	Creatinine.	Creatinine per kilo.	Water.	Remarks.
May 19	850	1020	0·731	—	1·136 lit.	—
,, 20	850	1015	0·603	13·9 mgrm.	1·420 ,,	—
,, 21	900	1015	0·592	—	1·420 ,,	—
,, 22	1000	1020	—	—	1·420 ,,	—
,, 23	1260	1015	0·642	—	1·420 ,,	—
,, 24	820	1020	0·844	—	1·420 ,,	Bath.
,, 25	700	1015	0·544	—	1·420 ,,	,,
,, 26	720	1020	0·613	14·5 mgrm.	1·740 ,,	,,
,, 27	450	1015	0·554	—	1·420 ,,	,,
,, 28	1120	1015	0·565	—	1·420 ,,	,,
,, 29	600	1025	0·354	—	1·420 ,,	,,
,, 30	850	1015	0·550	—	1·420 ,,	Last bath.
,, 31	800	1020	0·526	13·1 mgrm.	1·420 ,,	—
June 1	1040	1020	0·787	—	1·420 ,,	—
,, 2	1120	1015	0·515	—	1·420 ,,	—
,, 3	1340	1015	—	—	1·420 ,,	—

M. E. W—. Adolescent dementia. Patient took food well. The creatinine excretion remained fairly constant throughout, and was not influenced by the warm bath treatment to any great extent. The maximum figure was 0·844 and the minimum figure 0·354 grammes. The creatinine co-efficient is low.

Table X.

Warm baths, 100° F.—R. C—, male, æt. 25. Hypochondriacal delusions about gastric region; secondary depression. Weight on commencing baths, 57·3 kg.; weight on ceasing baths, 58 kg. Height, 1·67 metres.

Diet.—Ordinary male diet. (Amounts of constituents of diet as in Table VII.)

R. C—. This patient showed an increase in weight as a result of the treatment, but no mental change. The inconsistency in the volume of urine excreted is well marked, and if an average value be taken extending over three days, the excretion is found to be within the normal variations of excretion in the insane.

Twenty-four hours' sample.

1909	Vol.	Sp. gr.	Reaction.	Appear-ance.	Creati-nine.	Creatinine per kilo.	Remarks.
Nov. 22	840	1025	Acid	—	0·924	14·0 mgrm.	—
,, 23	650	1020	,,	—	0·605	—	—
,, 24	740	1030	,,	+	0·886	—	—
,, 25	710	1030	,,	+	0·946	—	—
,, 26	680	1030	,,	+	0·999	17·0 mgrm.	Warm bath 27th.
,, 28	570	1028	,,	+	0·914	—	—
,, 29	Lost		—		—	—	—
,, 30	320	1030	Acid	+	0·640	—	—
Dec. 1	470	1030	,,	+	0·813	13·2 mgrm.	—
,, 2	400	1030	,,	+	0·82	—	—
,, 3	430	1037	,,	+	0·98	16·7 mgrm.	—
,, 4	590	1035	,,	+	1·19	—	—
,, 5	810	1016	,,	—	0·737	—	—
,, 6	960	1025	,,	—	1·228	16·0 mgrm.	Last bath.
,, 7	720	1025	,,	—	0·856	—	—
,, 8	890	1020	,,	—	0·901	—	—
,, 9	1000	1020	,,	—	0·92	—	—
,, 10	670	1030	,,	—	1·10	—	—

Table XI.

Warm baths, 100° F., January 16th–27th, 1910.—J. R—, male, æt. 32. Subacute melancholia. Weight on commencing baths, 55·7 kg.; weight on ceasing baths, 58·1 kg. Height 1·7 metres.

Twenty-four hours' sample.

1910	Vol.	Sp. gr.	Reaction.	Appearance.	Creatinine.	Creatinine per kilo.
Jan. 14	2500	1010	Acid	—	1·00	21·3 mgrm.
,, 15	2890	1012	,,	—	1·38	—
,, 16	2095	1012	,,	—	0·963	—
,, 17	1400	1020	,,	—	0·938	—
,, 18	1130	1012	,,	—	0·508	—
,, 19	2370	1015	,,	—	1·266	—
,, 20	1570	1015	,,	—	0·942	—
,, 21	1620	1015	,,	—	0·891	—
,, 22	1470	1015	,,	—	0·735	—
,, 23	1470	1015	,,	—	0·735	—
,, 24	1590	1015	,,	—	0·815	14·6 mgrm.
,, 25	1490	1015	Alkaline	+	0·745	—
,, 26	1590	1015	,,	+	0·540	—
,, 27	1560	1015	,,	+	0·702	—
,, 28	1620	1018	,,	+	0·729	—
,, 29	950	1015	,,	+	0·304	—
,, 30	1910	1010	Acid	—	0·611	—
,, 31	1700	1013	,,	—	0·875	—
Feb. 1	1980	1012	,,	—	0·910	12·4 mgrm.

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Diet.—Breakfast: Bread, margarine, coffee. *Dinner:* Meat or bacon, fish, vegetables. *Tea:* Bread, margarine, tea, eggs, milk. (Amounts of constituents as in Table VII.)

J. R—. Subacute melancholia with ideas of unworthiness. In addition to the ordinary diet the patient received two pints of milk, one egg, and milk puddings. During the warm bath treatment the patient did not take his food well. The warm baths in this case apparently had no influence on the excretion of creatinine. The preliminary observations were unfortunately curtailed, and in consequence the figures given above are not strictly representative.

Table XII.

Warm baths, 100° F.—J. L—, male, æt. 37. Melancholia. Weight before commencing baths, 54·8 kg.; weight on commencing baths, 54·8 kg.; weight on ceasing baths, 53·4 kg. Height, 1·62 metres.

Diet.—Ordinary male diet, and similar to that when undergoing treatment with electric baths.

Twenty-four hours' sample.

1909.	Vol.	Sp. gr.	Creatinine.	Creatinine per kilo.	Water.	Remarks.
May 11	350	1025	0·707	—	—	Preliminary observations.
„ 12	310	1015	0·339	12 mgrm.	—	
„ 13	350	1025	0·567	—	—	
„ 14	490	1030	0·264	—	—	
„ 15	575	1025	0·788	—	—	
„ 16	660	1015	0·554	—	—	
„ 19	500	1020	0·430	—	1·278 lit.	Warm bath.
„ 20	660	1015	0·567	11 mgrm.	1·278 „	„
„ 21	620	1020	0·694	—	1·278 „	„
„ 22	720	1020	0·813	—	1·278 „	„
„ 23	1043	1022	0·978	—	1·278 „	„
„ 24	410	1025	0·623	—	1·278 „	Last bath.
„ 26	940	1030	1·269	—	1·278 „	—
„ 27	880	1025	0·963	16 mgrm.	1·278 „	—
„ 28	580	1025	0·730	—	1·136 „	—

For comparison with Table VII.

Table XIII.

Warm baths, 100° F.—H. H—, male, æt. 30. Adolescent

dementia. Weight on commencing baths, 73·6 kg.; weight on ceasing baths, 74 kg. Height 1·76 metres.

Diet.—Breakfast: Bread, 226·72 grm.; margarine, 14·17 grm.; coffee, 0·568 lit. *Dinner:* Bread, 56·68 grm.; meat or bacon, 198·38 grm.; peas, 141·70 grm., or potatoes, 453·44 grm; water, 0·568 lit. *Tea:* Bread, 226·72 grm.: margarine, 14·17 grm; tea, 0·568 lit.

Twenty-four hours' sample.

1909.	Vol.	Sp. gr.	Creatinine.	Creatinine per kilo.	Water.	Remarks.
May 10	1430	1015	0·993	—	1·436 lit.	Preliminary observations.
„ 11	815	1025	1·043	—	—	
„ 12	1540	1015	1·540	14 mgrm.	—	
„ 13	890	1015	0·679	—	—	
„ 14	1450	1015	1·123	—	—	
„ 15	1095	1025	0·678	—	—	
„ 16	1052	1025	1·209	—	—	
„ 19	1650	1025	2·521	—	1·136 lit.	Warm bath.
„ 20	915	1030	1·346	20 mgrm.	1·136 „	„
„ 21	1160	1025	1·252	—	1·136 „	„
„ 22	920	1025	0·783	—	1·420 „	„
„ 23	1000	1030	1·390	—	1·278 „	„
„ 24	1250	1025	0·822	—	1·420 „	Last bath.
„ 25	1120	1025	1·411	—	1·420 „	—
„ 26	460	1030	0·570	12·4 mgrm.	1·420 „	—
„ 27	1110	1025	1·340	—	1·420 „	—
„ 28	1270	1015	0·857	—	1·278 „	—

H. H—. Adolescent dementia of long standing. This patient took his food well and gained in weight. The marked increase in the creatinine excretion, especially on May 19th, 20th, and 21st, is very striking, and at the same time difficult to explain.

Table XIV.

Warm baths, 100° F., January 24th to February 11th, 1910.—B. S—, female, æt. 43. Subacute melancholia. Weight on commencing baths, 55·8 kg.; weight on ceasing baths, 57·3 kg. Height, 1·54 metres.

Diet.—The same as patient M. A. T— (Table II*a*).

B. S—. Subacute melancholia, with ideas of unworthiness and suicidal impulses. This patient took all her food and improved somewhat in mind, and certainly in general health.

Twenty-four hours' sample.

1910.	Vol.	Sp. gr.	Reaction.	Appearance.	Creatinine.	Creatinine per kilo.	Remarks.
Jan. 20	1010	1015	Acid	Clear	0·555	—	—
,, 21	1220	1015	,,	,,	0·451	—	—
,, 22	Missed		—	—	—	9·9 mgrm.	—
,, 23	1620	1010	Acid	Clear	0·662	—	—
,, 24	1250	1010	,,	,,	0·537	—	Warm bath.
,, 25	1180	1016	,,	,,	0·826	—	,,
,, 26	1110	1014	,,	,,	0·477	10·9 mgrm.	,,
,, 27	1570	1010	,,	+	0·700	—	,,
,, 28	1780	1012	,,	—	0·712	—	,,
,, 29	1150	1017	,,	—	0·908	—	,,
,, 30	1820	1010	,,	—	0·728	—	,,
,, 31	680	1020	,,	+	0·496	—	,,
Feb. 1	2290	1012	,,	—	1·374	—	,,
,, 2	920	1018	,,	—	0·908	—	,,
,, 3	1420	1015	,,	—	0·568	—	,,
,, 4	1050	1017	,,	—	0·787	—	,,
,, 5	1110	1010	,,	—	0·777	—	,,
,, 6	1260	1010	,,	—	0·604	13·8 mgrm.	,,
,, 7	1190	1015	,,	—	0·821	—	,,
,, 9	2210	1011	,,	—	0·917	—	,,
,, 10	1500	1012	,,	—	0·750	—	,,
,, 11	1020	1010	,,	—	0·408	—	,,
,, 12	1390	1014	,,	—	0·695	—	—
,, 13	1125	1018	,,	—	0·711	—	—
,, 14	1680	1010	,,	—	0·84	12·4 mgrm.	—
,, 15	1010	1014	,,	—	0·626	—	—
,, 16	1018	1016	,,	—	0·606	—	—

The creatinine excretion is low, and is almost unaffected by the treatment. The baths were repeated on fifteen consecutive days so as to be comparable with the electric bath treatment extending over a similar period. The gradual decrease in creatinine metabolism is not shown in this table (*cf.* Table VII).

Summary of Results.

An examination of the tables reveals the lack of uniformity in the secretion of urine, and for purposes of comparison the amount of actual fluid taken daily is given.

Folin noted the same variations in the volume of the urine in the patients he examined at the McClean Hospital for the insane.(3)

A possible explanation can be offered in the case of J. L— (Table VII), where this apparent abnormality is very well marked. The patient suffers from ptyalination, and in

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consequence loses a considerable amount of water in his saliva. Since creatinine excretion is constant for each individual from day to day, it serves as a valuable means of detecting any loss of the twenty-four hours' sample. In all cases where such a discrepancy has been detected the results have been discarded. Consequently the occurrence of any loss of the total quantity excreted cannot account for this feature. The patient may possibly eliminate large quantities of water in the expired air and the sweat.

There is also a tendency for some patients to retain urine, but this error is obviated by taking the average excretion of creatinine over three successive days. The creatinine values show the normal variations as regards weight, age, and sex. The question of age hardly affects these results, as the ages of the patients are mainly between twenty-four and thirty-eight years.

The excretion of creatinine was observed at least three days before the baths began, and showed values of from 11 to 16 mgrm. per kilo. of body-weight in the case of the women patients, and from 12 to 24 mgrm. per kilo. of body-weight in the men.

As a result of the electric bath treatment the creatinine figure was increased with one exception, *e.g.*, J. O'B— (Table VI). The creatinine co-efficient in the female patients varied between 13 and 23 mgrm. per kilo. of body-weight, and in the men from 15 to 21 mgrm. per kilo.

After cessation of the baths the excretion of creatinine showed a slight diminution, but in only two cases did it fall below its former value.

The effect of the warm baths, on the other hand, was to lower or increase the excretion of creatinine to a very slight extent, and in only two cases did the figure rise much above its former level.

These observations are in accord with those recorded by Tuttle (4) on the effects of different kinds of warm baths installed at the McClean Hospital for the Insane. Folin investigated the metabolism in nine cases treated in this way, and found no definite changes. The creatinine figures are, however, not given.

A comparison of the values given above with those obtained

by other observers for the insane reveals the fact that in the electric bath cases there is a most decided increase in creatinine during the period of the baths. This increase rapidly reaches a maximum value and then gradually falls, and this fall is most marked when the treatment is prolonged (see Tables II, III, and VII).

A series of electric baths of short duration seems to be more beneficial than a single series of long duration (compare Table II*a* with Table II).

The difference between the two forms of treatment is most strongly marked in the case of J. L—. He received warm baths from May 19th to May 24th inclusive, and during that time the creatinine co-efficient was 11 mgrm. per kilo. On October 14th of the same year an electric bath was given, and repeated daily until November 1st. During the first week the excretion of creatinine gradually increased, reaching a maximum during the second week of treatment. Subsequently the value gradually fell to its former level. Reference to Table VII will show the co-efficient increased from 12 mgrm. to 17 mgrm. per kilo. of body-weight.

Now what is the significance of this increase? The creatinine in the urine is now recognised to be entirely of endogenous origin, and intimately bound up with the muscular system. Although there is evidently a rough proportionality between the body-weight and creatinine excretion, the bulk of muscle seems to play a prominent *rôle*. However, it is difficult to completely reconcile all the facts with these two views. All the patients examined showed very little muscular development or muscular efficiency, hence the low figures obtained.

The results seem to support Shaffer's view that creatinine is an index of a special process of metabolism taking place in the muscles, and that the muscular efficiency depends upon it. Exposure of the muscles to a sinusoidal current probably intensifies this process, increasing the general tone of the muscles, and consequently the creatinine metabolism. The effect of electric baths on these patients affords considerable support to this view, not only from the aspect of creatinine metabolism, but also from the clinical observations.

With regard to the origin of creatinine, a valuable and interesting contribution has been made by Waldemar Koch (7). He points out the close chemical relationship between lecithin

and creatinine, and thinks that the latter is derived from the disruption of lecithin molecules.

In this connection it is interesting to note that the increase of creatinine was always accompanied by an increase in inorganic phosphates in the urine.

The results recorded above, although not definitely conclusive, seemed to be of sufficient interest to warrant publication. A much more detailed investigation is, however, necessary, and we hope at a later date to contribute further observations on this subject. As far as is possible the same patients will be examined to obtain the creatinine excretion extending over the same periods of time, but without adopting any bath treatment. It also seems necessary to investigate the effects of baths on the normal healthy individual, and also on other pathological subjects besides the insane, especially patients with muscular atrophy.

Conclusions.

(1) The excretion of creatinine in the insane is in general subnormal.

(2) Electric bath treatment, using the sinusoidal current, tends to increase the creatinine in the urine.

(3) Treatment with warm baths without the current has very little, if any, influence on the creatinine excreted.

(4) The variations in volume of the urine excreted and the great proneness to bacterial decomposition seem to be characteristic of the insane.

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Discussion,

At the Quarterly Meeting at Leicester, February, 1910.

The President said he was sure all present were highly delighted with the most elaborate paper of Dr. Goodall and Mr. Mackenzie Wallis, which was stamped with the evidence of a great deal of labour, time, and thought. The authors seemed to have taken the hydro-electric treatment of mental diseases entirely out of the region of pure empiricism, and to have erected it upon a plane of something like scientific investigation, producing, therefore, accuracy of result. He did not propose to enter into details, but he desired to ask the gifted authors whether it was regarded by the latest authorities that the amino-acids, glycosin, creatin, leucine, and so on, were the necessary precursors of urea formation during the protein metabolism in the tissues, particularly in the muscles; and if the creatinine which resulted from such changes in the muscle creatin, which Mr. Wallis found in the urine, was simply the surplus of those precursors which were eventually converted into ammonia and carbon dioxide, and so passed the liver and the kidney as urea. That appeared to be a very important point, and he would be glad to know whether there was a more simple mode of splitting off, as had been suggested by Drechsel's experiments, experiments which were quite classical, in which strong, alternating currents were passed through solutions containing proteid material. That was found not to bring those amido-acids into being, but carbon dioxide and ammonia. And it was suggested that that was the immediate and simple method which might occur in the human economy. Perhaps this might be too simple to explain what occurred in the human economy; and he would like to know whether recent research upheld the possibility of this occurring, because he had never yet seen a reply to Professor Halliburton's question, that if those amido-acids were the precursors to urea formation from proteid metabolism, why did one not find them more freely escaping into the blood and passing on into the liver in ordinary metabolism, in the forms of leucine, glycosine, and creatinine in very great abundance?

Dr. Percy Smith desired to congratulate his late colleague, Dr. Goodall, and Mr. Mackenzie Wallis on the paper which they had produced. Dr. Goodall would remember that many years ago tepid baths were used a good deal at Bethlem Hospital in the treatment of certain excited and maniacal cases, and with the greatest possible benefit. There was no doubt that, as a result, patients who were excited became calmer—whether *post hoc* or *propter hoc* was another question—and there was general improvement. They gained weight, their sleep came back,

and eventually they recovered. Therefore, he was interested in Dr. Goodall's statement that short baths were preferable to long ones. He was speaking purely of warm baths, as in those days they had no sinusoidal current, and no means of obtaining proper electric baths. He believed Dr. Goodall said there were 108 cases treated, and that 62, or 57·4 *per cent.* recovered or were mentally improved; so that 46 did not improve. And the author compared those 108 cases which had been treated by the electric current and bath with 16 others who had the warm-bath treatment only. He thought it was rather unfortunate, for purposes of comparison, that a larger number—for instance an equal number—were not treated by pure warm baths. Of the 16 cases treated in the latter way the author said those who did not improve on that method were the patients who did not gain weight. One knew that gaining weight was a common accompaniment, if not the cause, of the improvement in many acute mental cases. And of course the improvement in the cases which were treated with the electric bath was most marked in those who were physically weak at first; and no doubt physical improvement was going on—whether concurrently with it, or because of it, was a matter on which there was room for doubt. He was very much interested in the question of the increased excretion of creatinine in the cases treated by the electric bath. It occurred markedly in one of the sixteen cases treated by mere warm bath, without electricity; and the investigation raised the question as to whether the creatinine was the elusive toxin for which everyone seemed to be looking as the prime cause in mental disease. Many said that a toxæmia of some form was at the root of insanity. He would like to hear the views of the authors on that point: whether they thought the investigation brought the profession nearer to the causal agent in mental disorder.

Dr. G. Scott Williamson said he would like to congratulate the authors of the paper on its supreme value, and also remarked on the fact that it was the first attempt in the annals of British psychology to tackle the functional abilities of the insane. A number of workers were taking up the question in America, but even there the workers at the subject were few. A contribution like the present one was supremely welcome. With regard to creatinine, he would like to mention some observations which he made some time ago with regard to a condition in which there was undoubted toxæmia, namely, in tuberculosis, and especially phthisis. The patients in question were all undergoing sanatorium treatment, and, as a result of that, some of them were increasing in body-weight. But the creatinine in no way varied with such increase in body-weight. Every three or four weeks the amount of creatinine was estimated, and it was found to be that of a practically normal individual, although some of the patients had pronounced cavitation and toxæmia, as evidenced by their rise and fall of temperature. The increase in body-weight owing to the sanatorium treatment presumably meant a pure increase of fat. With regard to the patients who were undergoing the graduated labour treatment at the sanatorium—and presumably, from the estimation of their opsonic indices, they were overcoming their toxæmia and neutralising some of it—in them, as the weight increased, the creatinine showed signs of rising, but not sufficiently to enable one to say that the increase was *pari passu* with the increased body-weight, *i.e.*, that the muscles were functionally capable of breaking up and giving rise to more creatinine. In the patients who were subjected to inoculation treatment, one found that if one induced a very profound negative phase, *i.e.*, a condition of hypertoxæmia—perhaps the toxæmia was very different, and might have differed from the circulating toxæmia, as it was an endotoxæmia coming from the bacillary bodies themselves—the creatinine showed a very profound fall. In a patient who was losing much weight the creatinine remained markedly stationary. Those observations were not sufficient on which to form any conclusions, but he thought they were worth relating, and might, perhaps, help to elucidate some of the problems brought forward by Dr. Goodall and Mr. Mackenzie Wallis.

Dr. Stoddart said that he had been wondering whether, after all, it was a good thing to get rid of the creatinine. He would like to know whether creatinine was really a body poison. Could anyone give information who had had experience of examining the creatinine excretion in normal people? If so, he would be glad to know whether the sinusoidal current increased the creatinine excretion of the average normal person. He did not know whether Dr. Goodall adopted the same classification as he did himself; but the cases which Dr. Goodall mentioned as

being treated by sinusoidal current all seemed to him cases which one would have expected to recover under the treatment hitherto commonly adopted. With regard to the treatment by plain warm baths, his experience practically coincided with that of Dr. Percy Smith, namely, that warm baths certainly had a beneficial effect.

Dr. ROBERT JONES sent the following communication, which was read by Dr. Bond: I have tried the electric bath treatment in the case of adolescents mostly. In these, as also in some adults, the form of insanity was that of melancholia. Some of the cases presented well-marked melancholia attonita and the so-called anergic stupor. Most of these cases are characterised generally by gradual deterioration; they stand or sit about in a fixed or passive attitude, and have almost always to be considerably coaxed (if not forcibly fed) in order to get them to take nourishment. The mental condition is so unsatisfactory that some authorities call the disease "primary dementia" or "dementia præcox," and it is certainly not a very curable form. After consultation with Dr. Lewis Jones and the encouragement experienced by using a simple method of electric bath treatment, I tried it upon eighteen male and five female patients. The five female cases improved greatly in health; two were phthisical, and whilst undergoing the electric bath treatment both of them gained several stones in weight. One of them died later of phthisis, but the other was discharged recovered; the third recovered, the fourth developed epilepsy, and the fifth remains at present as a helper in the asylum. In addition to these cases the electric bath treatment was used for certain cases of puerperal insanity, and it was considered to be a help towards restoration. Of the eighteen men, nine have left the asylum (six recovered, two were discharged relieved, and one has improved but not recovered). All the men gained weight under treatment, being weighed weekly, and the record has been kept, the average gain of the nine who left the asylum being seven pounds during the bath treatment, which lasted for an average period of seven weeks, but some received baths for nine or eleven weeks. The maximum gain in one case whilst under treatment was twenty-two pounds, the next highest being seventeen pounds. Of the nine cases remaining under treatment one was phthisical, one was suffering from progressive muscular atrophy; the others are considerably improved mentally, the stupor or profound melancholia having quite passed off. Upon the whole I consider the results to be satisfactory. So little has yet been done in regard to the systematic treatment of the different forms of insanity by electro-therapy that it is, perhaps, premature to formulate any definite conclusion, but I consider that in electric baths we have an excellent and valuable stimulant to metabolism. The skin in the insane is in an abnormal condition, but whether the improvement after baths is due to increased elimination, or due to vascular changes brought about by the bath, or whether it is due to increased nervous stimulation and metabolism, I am not prepared to say. I should especially recommend this treatment in the melancholia of adolescent and apathetic cases such as I have referred to.

Dr. GOODALL, in reply, said he was glad to find the paper had aroused so much interest. He would leave his colleague to answer the points concerning the creatinine excretion. Dr. Percy Smith commented on the paucity of the controls. He, Dr. Goodall, agreed that sixteen control baths were few, and he would be pleased to see the results in a larger number. But, as he had intimated, it was an arguable point how far it was justifiable to conduct such control experiments, since merely putting a patient into a bath at a temperature of 99°–100° F. for twenty minutes at a time scarcely constituted treatment. He had asked a friend at another asylum if he would make similar controls, to assist in getting a larger number of them, and that gentleman's reply was that he did not feel justified in doing so. Some of the patients had electric baths and warm baths as well, and they said the electric bath did them more good than did the plain warm bath. He thought that repeated warm baths, at increasing temperatures up to, say, 105° F., had a sedative effect, but this was an entirely different proceeding; he did not believe it could be shown that baths at the low temperature employed had a stimulating effect; certainly not such a tonic, stimulating effect as electric baths had. Dr. Lewis Jones, an authority on the subject, said that the latter were invigorating and stimulating in a number of cases. Dr. Lewis Jones had had a large experience in the matter, both in private and in hospital practice. In reply to Dr. Bedford Pierce, he would say that the effects of the sinusoidal current were improved by rhythmic variation. Dr. Stoddart had seemed to suggest that the

class of cases treated were those which got well if left to Nature and the nurse. To prove that the results were not due to the electric bath it would be necessary to ignore wholly the results of sixteen careful controls, and furthermore, to take an equal number of like cases, adopt no treatment, giving the same diet merely, and compare the ratio of recoveries and the recovery-period with those obtaining in the cases treated by current. He believed, as stated, that if he had reckoned the recovery-period in all cases from the time of commencing the bath treatment, it would have been found to be considerably shorter than that recorded.

Mr. MACKENZIE WALLIS, in reply, said he desired to thank his audience for having listened to such a long and tedious paper. In reply to the President, creatin was derived originally from amino-acids, because if one took the developing chick one found that there was no creatin at all, and in the hatched chick there was only a very small quantity. It was only after the fourteenth day from the hatching that one found the maximum amount of creatin in the muscles, and only after that stage was creatinine eliminated. There was practically no creatin given in the food of those chickens, and so creatin must be derived from the proteins of the egg. When the muscle had reached its saturation-point, creatinine was excreted—in other words, creatin was used up in muscle, and the surplus was converted into creatinine and excreted. The precursors which had been mentioned were possible ones, but there was no proof at present that those amino-acids were formed and absorbed as such, or in combination with each other. Possibly a number of amino-acids were united together, and for utilisation by the organism the nitrogen was split up and disseminated; and that nitrogen went to the liver and was converted into urea. The small amount which was required to maintain the wear and tear of the tissues, and also derived from amino-acids produced in digestion, represented the endogenous metabolism, and the body creatinine was included among the substances formed. With regard to the work of Drechsel, the splitting up of proteids by passing a strong current, it was possible that the result of the electric baths was to increase the protein-destruction in the body. Unfortunately, they were unable to investigate the subject owing to lack of apparatus; but it was hoped that that would be done in the future, and then they would have some idea whether the increase in the creatinine under electric bath treatment was concomitant with the increase in the other nitrogenous constituents. He was more inclined to Koch's view of the origin of creatinine, *i.e.*, from lecithin, rather than from amino-acids; but the lecithin itself was probably derived from amino-acids in the first place. Creatinine seemed to be indirectly connected with the destruction of lecithin. Dr. Percy Smith had mentioned the possible toxic origin. The creatin in the muscles was toxic; but when it was converted into creatinine—and it was a simple hydrolysis which took place in the liver—this creatin was rendered non-toxic. The former was a strongly basic chemical body, but it had no toxic effect. Creatin was constantly being produced in muscle, and the surplus was got rid of. It was necessary to convert the residue into an innocuous form, and that conversion was carried out by the liver, and the surplus was excreted. In the insane there was a very low excretion of creatinine, and it was possible that creatin in the muscles might be oxidised into some other body, and that other body might cause the toxic effect. By increasing the creatinine excretion, one eliminated the danger of conversion into some other, and probably more toxic, body. The origin from lecithin was suggested by the fact that lecithin was always being broken down; because even if phosphates were excluded from the food one still found organic phosphates in the urine. In answer to Dr. Williamson's remarks, there was always an increase of creatinine with an increase of temperature. If the oxidation of the tissues was lowered there was a consequent lessened excretion, and that might account for what Dr. Williamson had observed. It was creatin which was the poisonous substance, and the body converted that creatin into creatinine, and after that conversion it became innocuous. With regard to testing the effect of the electric bath on the normal person, that had not been done by his colleague and himself. It certainly should be, but possibly it would not show any effect at all. One might take all kinds of exercises, and increase the diet, but the creatinine excretion would not be affected in an ordinary individual by such means. Possibly a more liberal dieting of the patients under observation would have made a good deal of difference to the creatinine excretion. He did not think the routine nstitution diet was sufficient.