U. S. NAVAL RADIOLOGICAL DEFENSE LABORATORY
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Encl: (1) U.S. Naval Radiological Defense Laboratory Report USNRDL-TR-313 entitled "Total Exchangeable Potassium and Chloride and Total Body Water in Healthy Men of Varying Water and Fat Content" by E.A. Boling, W.L. Taylor, C. Entenman and A.R. Behnke, Project NM 62-03-60, Subtask 13

1. During the past twenty years the development of techniques to determine the total quantity of such substances in the living body as fat and water, and electrolytes such as sodium, potassium and chloride, represents a noteworthy achievement in medicine.

2. The senior author of enclosure (1) has developed and perfected techniques using radioisotopes of hydrogen, bromide, and potassium, beginning his investigations at Dr. Francis Moore's laboratory at the Peter Bent Brigham Hospital, Boston, and continuing the investigations at this Laboratory to the point where highly reliable data can be obtained with the administration of minimal quantities of radioactive tracer material. The total radiation received per individual was less than 0.2 rad.

3. An independent test on one subject, for example, revealed agreement within 3.5 per cent in exchangeable body potassium estimated by K^{40} data obtained in a whole body low radiation background counter and the exchangeable potassium estimated after injection of K^{42}. Likewise, close agreement was obtained in the tritiated water analyses.

4. The significance of these studies is far reaching. Since potassium is mainly in the body fluid within cells and chloride is mainly extracellular, the proportions of these electrolytes in relation to total body water constitute base-line indices of reference standards. Thus, the total red blood cell mass, basal oxygen consumption, cardiac output, and various other parameters can be related to the active cell mass as determined by its water and electrolyte content. Derangements in these reference standards may constitute the first signs of incipient disease, abnormal growth pattern, or sub-normal development.

Paul C. Tompkins
PAUL C. TOMPKINS
By direction

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TOTAL EXCHANGEABLE POTASSIUM AND CHLORIDE AND TOTAL BODY WATER IN HEALTHY MEN OF VARYING WATER AND FAT CONTENT

Research and Development Technical Report USNRDL-TR-313

23 March 1959

by

E. A. Boling
W. L. Taylor
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UNCLASSIFIED

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Biology and Medicine

Technical Objective
AW-6

Biochemistry Branch
C. Entenman, Head

Biological and Medical Sciences Division
Captain A. R. Behnke (MC) USN, Acting Head

Scientific Director
P. C. Tompkins

Commanding Officer and Director
Captain J. H. McQuilkin, USN

U. S. NAVAL RADIOLOGICAL DEFENSE LABORATORY
San Francisco 24, California

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ABSTRACT

During recent years it has been shown that various parameters and functions of body composition, among them exchangeable potassium, sodium, chloride, total red cell mass, plasma volume, indices of extracellular fluid volume, and creatinine excretion, all are quite closely correlated with the size of the lean body mass. This is true not only in man, but in a variety of lower animals.

Recent advances in methods have made it possible to measure exchangeable potassium using mixing times of 40 hours. Also, it has been shown that for sick patients, a mixing time at least this long should be used for purposes of accuracy Most of the data in the literature for exchangeable potassium in healthy men has been gathered using mixing times of 24 hours.

In addition, it has been reported that gains or losses of weight have been associated with alterations in both extracellular fluid and total body water. Because of these factors, measurements of exchangeable potassium, exchangeable chloride, and total body water were performed in a group of 36 healthy men of varying water and fat content.

The results showed a marked correlation between the amount of exchangeable potassium or chloride in the body and the amount of water in the body. In addition, it was seen that the amount of exchangeable chloride increased in proportion to the relative amount of fat in the body, and decreased in proportion to the relative amount of water in the body. Fat men contained relatively more

chloride per unit of body water than did average men, and average men contained more than did lean men. No such relationship was present for the amount of exchangeable potassium, which was constant, with relation to the body water, over a wide range of water or fat content.

ADMINISTRATIVE INFORMATION

This work was accomplished under the Bureau of Medicine and Surgery Task Number NM 62 03 60, Subtask 13, Technical Objective AW-6, as described in the U. S. Naval Radiological Defense Laboratory Annual Report to the Bureau of Medicine and Surgery (DD Form 613-1) of 31 December 1958, and is listed in the U. S. Naval Radiological Defense Laboratory Fiscal Year 1959 Technical Program under Program A3, Problem 1. This study was supported through funds provided by the Bureau of Medicine and Surgery and the Office of Civilian and Defense Mobilization.

ACKNOWLEDGEMENTS

The authors wish to express their appreciation to Dr. I. S. Edelman and Dr. K. G. Scott, of the University of California Medical School, for invaluable help and advice during the course of this project. Mr. Hyman H. Hechter of this Laboratory rendered valuable assistance in the statistical evaluation of the data.

SUMMARY

Exchangeable potassium, exchangeable chloride, and total body water were determined in a group of 35 healthy men of widely varying degrees of fatness, using K^{42}, Br^{82} and tritiated water as tracers. The methods used permitted these measurements with isotope doses such that the radiation dose was only 0.14 rad. K_e and Cl_e were compared with the total body water. A high degree of correlation was found for both of these regressions. Each correlation coefficient was 0.96. In addition, a regression is shown which indicates that the obese men in this study contained proportionately more chloride than did the average men, and the average men contained proportionately more chloride than did the lean men. For ten fat men containing less than 55% water by weight, Cl_e/TBW was 53.0 mEq. liter. For ten average men containing between 55% and 60% water by weight, Cl_e/TBW was 51.5 mEq./liter. For eight lean men containing more than 60% water by weight, Cl_e/TBW was 49.3 mEq./liter. These differences are significant ($0.01 > P > 0.005$). No such differences were found when the regression K_e vs. TBW was examined in these three groups. It was pointed out that the above relationship between Cl_e/TBW and TBW/wt. may not be primarily related to obesity, since the dietary salt intake of these men was not controlled prior to the study.

INTRODUCTION

During the past few years several articles have appeared in which evidence has been given showing close correlation between the lean body mass, or some function of it, and those parameters of body composition which are primarily related to the aqueous phases of the body. Weir measured exchangeable chloride (Cl_e) in dogs by observing the dilution of stable bromide. He also measured the carcass chloride in these same dogs. He found poor correlation between exchangeable chloride and body weight (1). However, he found a much better correlation between Cl_e and fat-free carcass weight (2). Cheek and West (3) found that K_e, carcass potassium, Cl_e, and carcass chloride in rats were closely related to both the fat-free carcass weight and to the total body water. Muldowney (4,5) measured K_e, Cl_e, total body water (TBW), plasma volume and red cell mass in adult human beings, and compared all these with lean body mass, derived from TBW, and with creatinine excretion. He found that the correlation of each parameter with lean body mass was significantly better than its correlation with body weight or surface area. McMurrey et al (6) measured Cl_e, K_e, Na_e, red cell mass, plasma volume, and TBW in a group of ten healthy men and ten healthy women. Their data show significantly better correlation of these parameters with body water than with body weight.

Recently, O'Meara et al. (7) have found that the mixing of administered K^{42} is prolonged in subjects who have edema. It was concluded by these authors that equilibration times should be extended to 40 hours when measuring K_e in sick

patients. Recently, apparatus has become available by means of which it is convenient to measure K_e using a mixing time of 40 hours, using only 50 microcuries of K^{42} (8,9).

It has been reported (10) that fluid changes may accompany gains and reductions in weight. In the present investigation exchangeable chloride, exchangeable potassium, and body water were measured in a group of healthy men of varying degrees of fatness, and the values obtained were compared in order to observe any changes which might be related to obesity.

METHODS

Subjects

Thirty-seven healthy adult men were studied. Food and water were taken ad libitum during the first 16 hours of the experiment. A diet low in potassium was prescribed for the remaining 24 hour period. On the equilibrium morning, no food or water was permitted. All urine was collected during the entire procedure, for determination of the amount of isotope excreted.

Dosage

Each person received an intravenous injection of 50 microcuries of K^{42}, given 40 hours prior to equilibrium sampling, and an intravenous injection of 5 microcuries of Br^{82}, given 24 hours prior to equilibrium sampling. An intravenous injection of 1 millicurie of H^3 as tritiated water was given each subject on the morning during which equilibrium of K^{42} and Br^{82} distribution occurred. All injections were sterile and isotonic and were administered using calibrated syringe-pipettes in volumes of 20 ml. These pipettes delivered volumes which were reproducible within 0.02 ml.

Sampling

All urine was saved by each subject during the entire experiment. The first night's urine, containing only K^{42}, was counted separately. The urine voided subsequently contained both K^{42} and Br^{82}, and was processed prior to counting, as will be described.

Upon arising on the morning of equilibration, each subject voided into his excretion collection bottle. Two successive spot urine samples were then collected, usually at 9:30 a.m. and 11:30 a.m., for determination of potassium specific activity.

Venous whole blood samples were removed 40 hours after the K^{42} injection (24 hours after the Br^{82} injection). These were allowed to clot and the serum was separated and used for determination of Br^{82} specific activity.

At this time, the tritiated water dose was given. Two and three hours afterwards, venous whole blood samples were collected for total body water estimation. The serum was separated and was stored in a freezer.

Counting

All samples which contained Br^{82} were counted as 15 ml. aliquots in a sodium iodide thallium-activated scintillation well counter. The serum samples were counted in triplicate, 10,000 counts being collected for each sample. Urine excretion samples were counted in duplicate. Duplicate dilutions of the injected material were made and were counted in triplicate.

The samples which contained K^{42} were counted in volumes of 80 ml. in a beta well counter (8,9). Those urine samples which contained Br^{82} in addition to K^{42} were treated by the addition of a measured excess of $AgNO_3$, followed by suction filtration through an asbestos filter. This procedure effectively removed all Br^{82},

The filtrate was then used for K^{42} counting. Excretion samples were counted in duplicate. Equilibrium samples were counted in quadruplicate, 10,000 counts being collected for each sample.

Serum samples containing H^3 were kept frozen between collection and assay. They were then thawed, and were vacuum distilled from the frozen state (11). Samples were prepared in duplicate by pipetting 1.0 ml. samples of distilled serum water into glass vials, adding 18 ml. of liquid scintillant, and counting the vials in a liquid scintillation spectrometer. Dilutions of the injected material were distilled, prepared and counted along with the serum water in each case.*

Chemical Determinations

Potassium determinations were done by internal standard flame photometry, using a Baird Associates flame photometer. Serum chloride determinations were done by a potentiometric titration based on the method of Sanderson (12).

Calculations

In calculating the exchangeable potassium, all beta well counter data were first corrected for background and for radioactive decay. Only solutions containing K^{42} alone were counted in this apparatus. A specific gravity correction was also necessary (8,9). In addition, those excretion samples which were processed to remove Br^{82} were corrected for the volume of $AgNO_3$ solution which was added in each case. The reduced data were then used to calculate K_e by the expression

$$K_e = \frac{A - E}{S.A.}$$

* We wish to thank Dr. I. S. Edelman, of the University of California Medical School, for his most helpful assistance and advice in setting up this technique.

where K_e = exchangeable potassium, mEq.

A = counts per minute injected

E = counts per minute excreted

S.A. = specific activity, counts per minute/mEq.

In calculating the exchangeable chloride, all of the NaI:Tl scintillation well counting rates were corrected for background. Since all of the Br^{82} samples counted also contained a certain amount of K^{42}, it was necessary to correct for this. For the excretion urine sample, the correction was based upon the ratio

$$\frac{K^{42} \text{ counts/minute/15 ml. sample (NaI:Tl well counter)}}{K^{42} \text{ counts/minute/80 ml. sample (beta well counter)}}.$$

This ratio was 0.1547 for the two counters used. To obtain the K^{42} counting rate of the excretion urine in the NaI:Tl counter, the beta-well counting rate of the halogen-free filtrate was multiplied by this factor. After further being corrected for decay, this correction was subtracted from the total NaI:Tl counting rate. The remaining Br^{82} counting rate was then corrected for decay. For the serum samples, a correction for the K^{42} contribution to the NaI:Tl counting rate was also based upon the K^{42} ratio in the two counters, using the specific activity of $K^{42}:K^{39}$. This correction was always quite small, never being more than 17 c.p.m. in any of these subjects, compared with the total serum counting rate of perhaps 400-500 c.p.m. Errors in the determination of these K^{42} contributions to the NaI:Tl counting rates could have no significant effect upon the accuracy of the measurement of Cl_e.

Total body water was calculated assuming 0.16% excretion per hour during the 3-hour period of equilibrium (7) by means of the standard formula. The values represent water at 20°C.

The data for Cl_e and K_e in the last 22 men in this series were calculated from the raw data by a high speed electronic digital computer. One week's computation, ordinarily requiring about 6 hours work, was done by this means in 4-1/2 minutes.

RESULTS

The results of measurements of exchangeable potassium, exchangeable chloride, and total body water are given in Table I. In addition, the age and weight of each subject is listed. Values are given for Cl_e/wt, Cl_e/TBW, K_e/wt, K_e/TBW, and Cl_e/K_e. Water content is given as TBW/weight. The mean of each parameter and each ratio is given. Correlation coefficients are listed for Cl_e/TBW and K_e/TBW. In addition, the difference between the K^{42}/K^{39} specific activity of the first equilibrium urine sample in each subject, and that of the second sample, voided about two hours later, is listed as a percent of the mean specific activity for those two samples.

The regressions of K_e and Cl_e on body weight are shown in Fig. 1* and Fig. 2, respectively. These regressions show a considerable amount of scatter about the mean. In addition, both of these parameters show little increase beyond a certain maximum amount. In the case of potassium, this point is reached at about 5000 mEq. of exchangeable potassium. Further increases in the body weights of the subjects are not associated with marked increases in K_e. A regression starting at the origin and being tangent to the left hand, or upper, margin of the dots, which represent the data, could be used to symbolize those persons who were quite lean. By comparing this line with the largest person in our series, subject LC, it is seen that this person contains some 65 Kg. of weight which is not associated with K_e.

* All figures appear at end of text, beginning on page 13.

TABLE I

BODY COMPOSITION IN HEALTHY MEN

Age	Wt (kg)	TBW L	TBW % Wt	Cl_e mEq.	Cl_e mEq/L TBW	Cl_e mEq/kg	K_e mEq.	K_e mEq/L TBW	K_e mEq/kg	Cl_e/K_e	K^{42} S.A. Difference %
56	93.6	48.5	51.8	2561	52.8	27.3	4242	87.5	45.3	0.604	2.45
21	62.7	39.1	62.4				3277	84.3	52.3		1.90
32	73.6	38.8	52.7				3378	87.1	45.9		9.20
20	64.3	37.0	58.5	1809	48.9	28.1	3534	94.2	55.0	0.510	
43	52.4	30.6	58.4	1532	50.1	29.2	2434	79.5	46.4	0.629	
45	82.2	44.8	54.4	2375	53.0	28.9	3976	88.9	48.4	0.597	0.90
36	69.0	38.4	55.6	1947	50.7	28.2	3377	87.9	48.9	0.576	4.19
45	75.4	40.0	53.0	2117	52.9	28.0	3316	82.9	44.0	0.638	3.40
22	81.8	50.0	61.1				4404	88.1	53.8		0.53
26	74.3	43.4	58.4				4010	92.4	54.0		2.11
21	79.5	41.7	52.4	2248	54.0	28.3	3700	88.8	46.5	0.607	1.49
2	74.1	44.3	59.8	2276	51.4	30.7	3781	85.4	51.0	0.602	1.08
23	62.7			2001		31.9	3682		58.7	0.543	2.12
34	85.4	49.0	57.4	2665	54.4	31.2	4008	81.8	46.9	0.665	0.00
30	87.0	46.8	53.8	2248	48.0	25.8	3988	85.2	45.8	0.563	1.78
22	73.6	43.0	58.4	2240	52.1	30.4	3862	89.8	52.5	0.580	1.60
28	89.5	52.4	58.5	2686	51.2	30.0	4572	87.2	51.1	0.587	1.93
34	81.2	45.0	55.4	2326	51.8	28.6	3830	85.1	47.2	0.607	0.41
23	77.6	48.8	62.9	2373	48.6	30.6	4307	88.2	55.5	0.551	1.52
25	77.7	43.2	55.7	2235	51.7	28.8	3662	84.8	47.1	0.610	3.38
29	67.6	38.8	57.4	1955	50.4	28.9	3313	85.4	49.0	0.590	5.16
37	58.2	38.0	65.3	1863	49.0	32.0	3019	79.5	51.9	0.617	1.42
39	98.6	47.9	48.6	2480	51.8	25.1	3940	82.2	40.0	0.629	0.37
25	70.9	45.5	64.2	2236	49.1	31.5	4265	93.7	60.2	0.524	0.30
35	74.8	46.5	62.2	2304	49.5	30.8	4287	92.0	57.2	0.539	0.54
24	94.5	57.5	60.8	2897	50.4	30.6	5196	90.4	54.9	0.558	0.62
26	79.3	49.7	62.7	2299	46.3	30.0	4611	92.9	58.1	0.499	1.69
22	83.4	51.6	61.9	2463	47.8	29.5	4956	96.0	59.4	0.497	1.99
30	78.6	53.0	67.4	2801	52.9	35.6	4625	87.3	58.8	0.606	
41	130.7	61.1	46.7	(4021)*	65.8	30.7	5282	86.4	40.4	0.761	0.27
28	104.2	50.4	48.3	(3311)	65.7	31.8	4329	85.9	41.5	0.765	0.12
26	124.6	52.5	42.1	(3617)	68.9	29.0	4378	83.4	35.1	0.826	0.76
31	111.9	49.5	44.2	2638	53.3	23.5	4211	85.1	37.6	0.626	2.80
27	83.6	[illegible]	54.8	2458	53.7	29.4	[illegible]	90.9	49.8	[illegible]	0.30
28	122.3	9	44.9	3058	55.7	25.0		85.8	38.5	[illegible]	0.36
39	170.4			3562		20.9	[illegible]		35.2	[illegible]	0.5
35	115.0	53.7	46.7	2886	53.8	25.1	4774	88.9	[illegible]	[illegible]	1.33

[illegible]	[illegible]	[illegible]	[illegible]	1947	[illegible]	28.2	3377	87.9	48.9	0.576	4.19
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		46.3	56.0	2356	51.2	28.2	4092	87.3	48.7	0.586	1.72
					r = 0.96			r = 0.96			
σ = 23.0		6.04		350			602				
C.V. = 26.7		13.3		14.8			15.0				
N = 37		32		28			32				

of text.

A similar comparison can be made for Cl_e vs. body weight (Fig. 2). In this diagram, three points are present (subjects JB, JD, and RR) whose values for exchangeable chloride are so far outside the group as a whole, as will be shown later, that they make visual inspection of this regression confusing. They are included in the data but have not been used in the statistical evaluation. All three of these people were studied during a single week. Ignoring the positions of these three dots, one sees a scatter which is similar to that seen for K_e.

Total body water is plotted against body weight (Fig. 3). Once again, it is seen that two persons having essentially identical absolute body water content can be different in weight by a twofold difference. The magnitude of this difference was this great for all three parameters.

On the other hand, comparison of K_e and Cl_e with the simultaneously determined TBW gives the distribution seen in Fig. 4. It was assumed that the regression passes through the origin. The regression line, $K_e = 87.77$ TBW, is shown with its 95% confidence limits. It is seen that markedly increased linearity of correlation is present over that seen with the comparison K_e vs. weight. The correlation coefficient for K_e:TBW in this group is 0.96.

The relationship of Cl_e to TBW is shown in Fig. 5. The regression line, $Cl_e = 51.4$ TBW, is shown with its 95% confidence limits. The correlation coefficient for this regression is also 0.96.

DISCUSSION

The possibility that other factors besides lean tissue mass may influence the body content of fluid and electrolyte has prompted Ljunggren (14) to investigate

Cl_e and K_e with respect to their regressions on water and body weight. He used a concept which proposed two categories of body tissue, namely non-obesity tissue (NOT) and obesity tissue (OT). His calculations indicated that, given certain assumptions regarding body composition, obesity tissue contains more chloride in its aqueous phases than does non-obesity tissue. This was also true of his data for corrected thiosulfate distribution volume. Keys and Brozek (10) have described alterations in body fluid and electrolyte content associated with obesity, or with change in weight.

In the attempt to ascertain whether any weight-dependent differences existed in those men who were studied, they were divided into three groups according to their water content. Those who were 55% or less water by weight fell into the fat group and were considered fat; those who were between 55% and 60% water fell into the second group, and were considered average; those who were more than 60% water comprised the third group, and were considered thin. Each of these groups contained about ten persons. For each of these groups, the regression of Cl_e vs. TBW was examined and a regression line was computed. These data, with the calculated regression lines, are shown in Fig. 6. The highest line refers to the fat subjects, the middle line refers to the average subjects, and the lowest line refers to the thin subjects. These lines are significantly different ($0.01 > P > 0.005$). This would indicate a higher chloride content in the fat persons than in the average ones, and a higher chloride content in the average persons than in the lean ones.

When this comparison was done for the regression of K_e vs. TBW, no such tendency appeared. The regressions of K_e vs. TBW in the three groups were not significantly different one from the other.

This comparison of Cl_e, TBW, and body weight can be better illustrated by a different graphic representation. If the ratio Cl_e/TBW, which relates chloride to the total body water (an index of lean body size) is plotted on the ordinate, and the ratio TBW/weight (an index of obesity) is plotted on the abscissa, the result for the 31 men whose Cl_e was measured is shown in Fig. 7. It is at once apparent that three of the points are vastly different from the rest. These are subjects JB, JD, and RR, representing all the determinations for a single week, who were mentioned in the discussion of the regression Cl_e vs. weight. They were not used in the statistical treatment. Excluding these men, a regression was computed for Cl_e/TBW vs. TBW/weight. This regression is shown, with its 95% confidence limits. Using this regression, and assuming a fat man and a thin one, each containing 40 liters of body water, we can calculate the probable Cl_e for these two men. Assuming extremes, i.e., 40% water content for the fat man and 65% water content for the thin man, the Cl_e for these men would be:

Fat:	40 L. x 56.5 =	2270 mEq.
Thin:	40 L. x 49.5 =	1980 mEq.
	Difference:	290 mEq.

This implies that the fat man would have an exchangeable chloride which would be equivalent to at least two liters of extracellular fluid more than the thin man would have.

It is not possible at this time to state a primary relationship between obesity and this regression. It has been pointed out by Strauss et al. (14), Strauss et al.(15), and by Leaf and Couter (16) that the body water content may be markedly influenced, over short periods of time, by the amount of salt consumed in the diet. Further conclusions regarding a relationship of chloride content to obesity must follow the collection of data under conditions which control this variable.

When the data of McMurrey et al. (6) are compared in the same way used in Fig. 7, a suggestion of regression is present if the men and women are considered as a group. However, neither the group of men alone nor the group of women alone is sufficiently numerous to permit statistical conclusions. The distribution of their data for Cl_e/TBW vs. TBW/weight is very similar to that of their data for Na_e/TBW vs. TBW/weight, which is shown in Fig. 8. It is seen that neither the men nor the women alone show any regression, but that either a regression or a sex difference is highly likely when the whole group is considered and the women are compared with the men.

When the data for exchangeable potassium in the present work are compared in the same way used in Fig. 7, the result is shown in Fig. 9. No suggestion of regression is present.

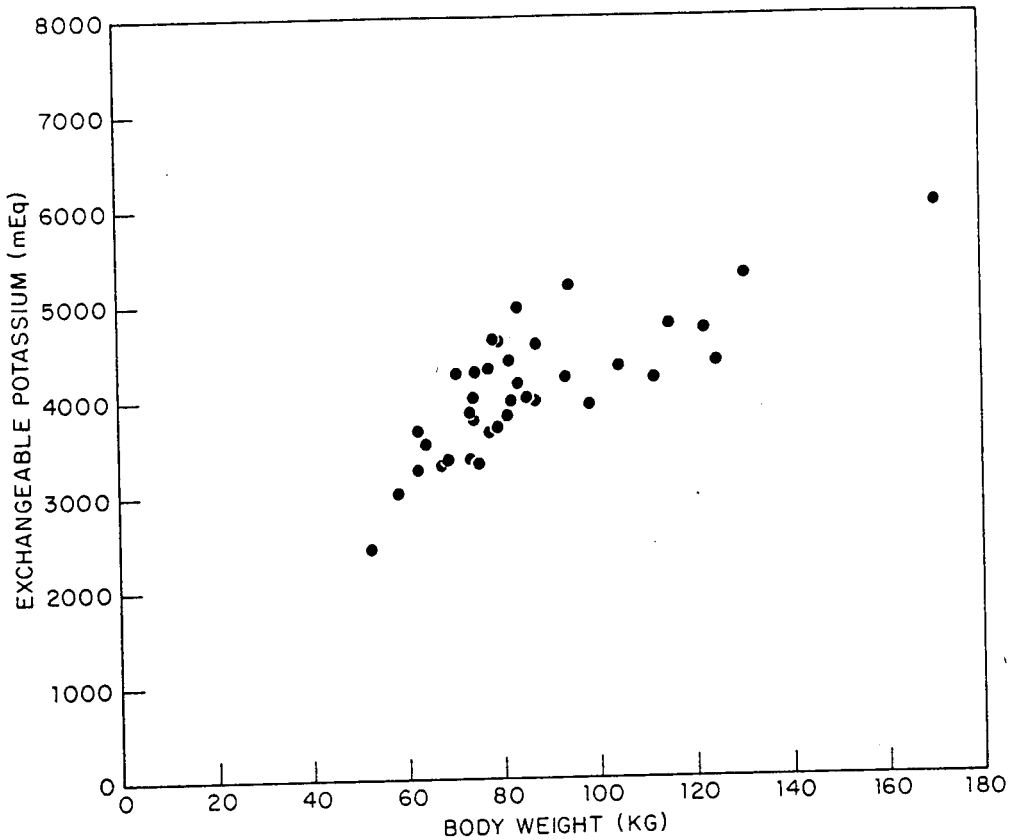
Approved by:

A. R. Behnke

A. R. BEHNKE
Captain (MC) USN
Acting Head, Biological and
Medical Sciences Division

For the Scientific Director

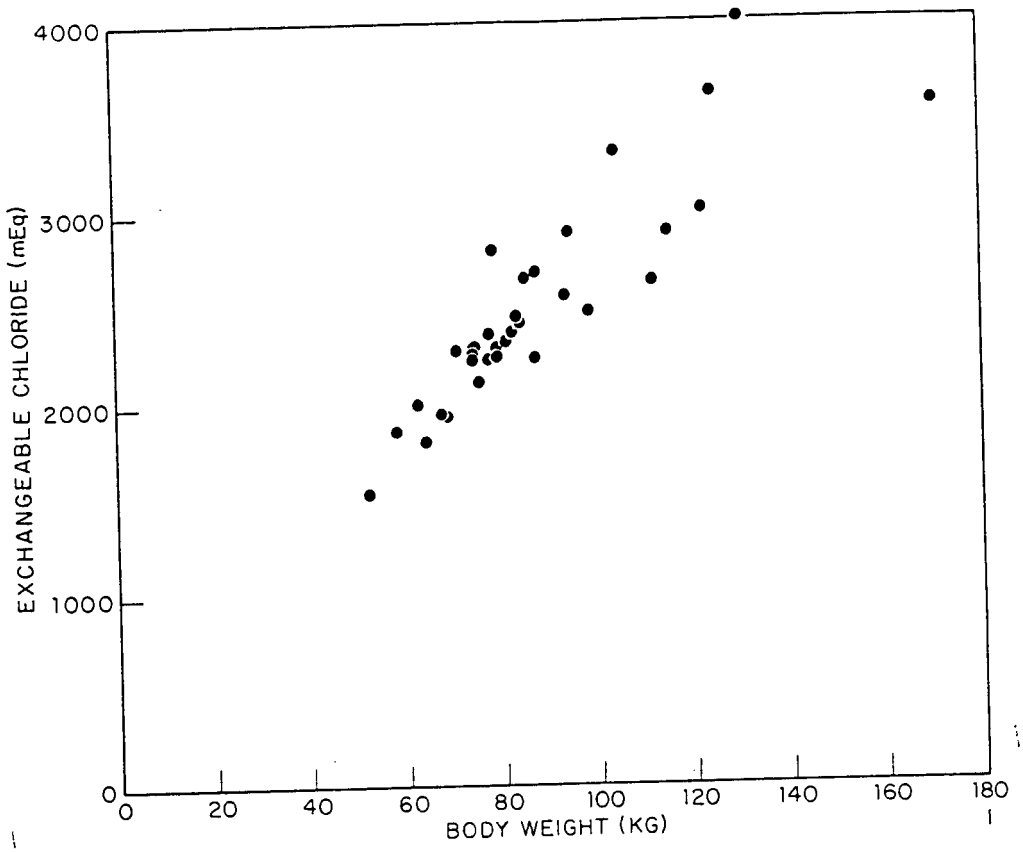
Fig. 1. Exchangeable potassium as a function of body weight. K_e is plotted on the ordinate. Body weight is plotted on the abscissa.


8000
7000
6000
5000
4000
3000
2000
1000
0
EXCHANGEABLE POTASSIUM (mEq)
0
20
40
60
80
100
120
140
160
180
BODY WEIGHT (KG)

Bolling

~~Eyf~~

Fig. 2. Exchangeable chloride as a function of body weight. Cl_e is plotted on the ordinate. Body weight is plotted on the abscissa.


4000
3000
2000
1000
0
EXCHANGEABLE CHLORIDE (mEq)
0
20
40
60
80
100
120
140
160
180
BODY WEIGHT (KG)

2

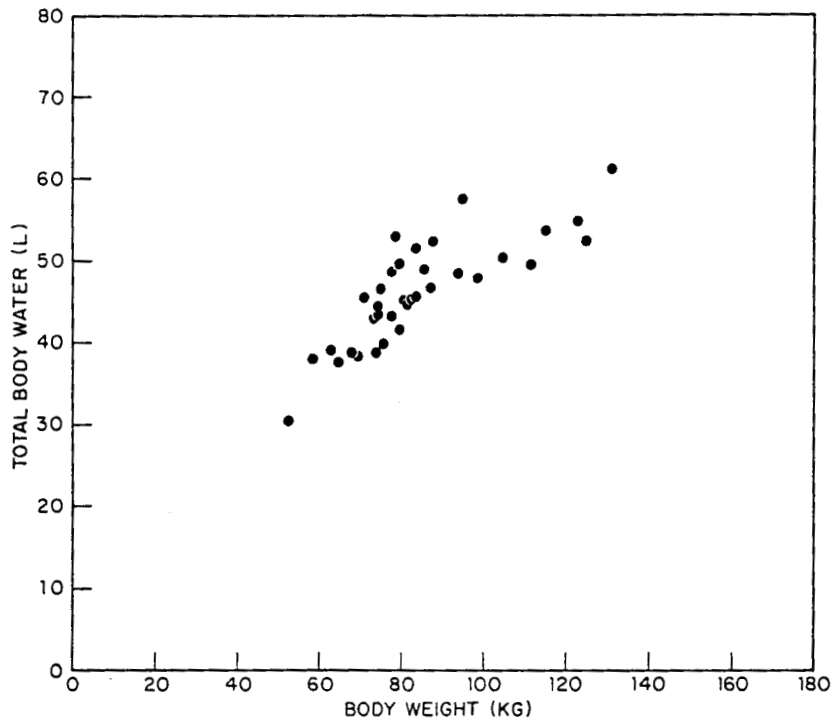


Fig. 3. Total body water as a function of body weight. TBW is plotted on the ordinate. Body weight is plotted on the abscissa.

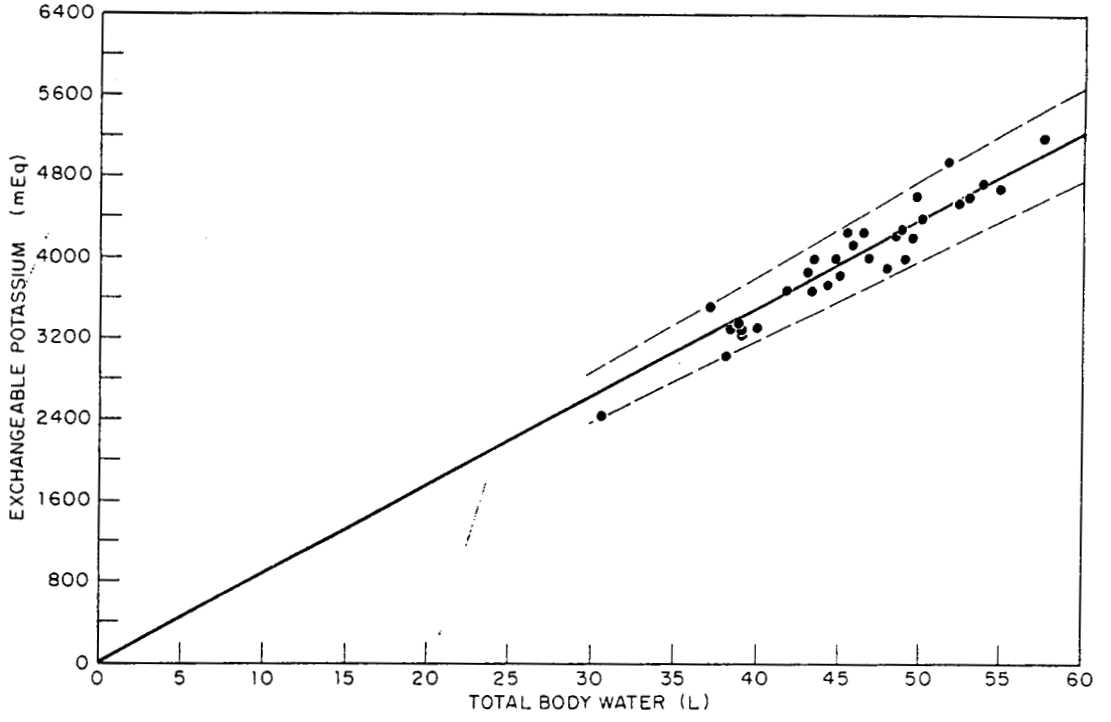


Fig. 4. Exchangeable potassium as a function of body water. K_e is plotted on the ordinate. TBW is plotted on the abscissa. It is assumed that the regression passes through the origin. The regression line, K_e = 87.77 TBW, is shown (solid line) with its 95% confidence limits (broken lines).

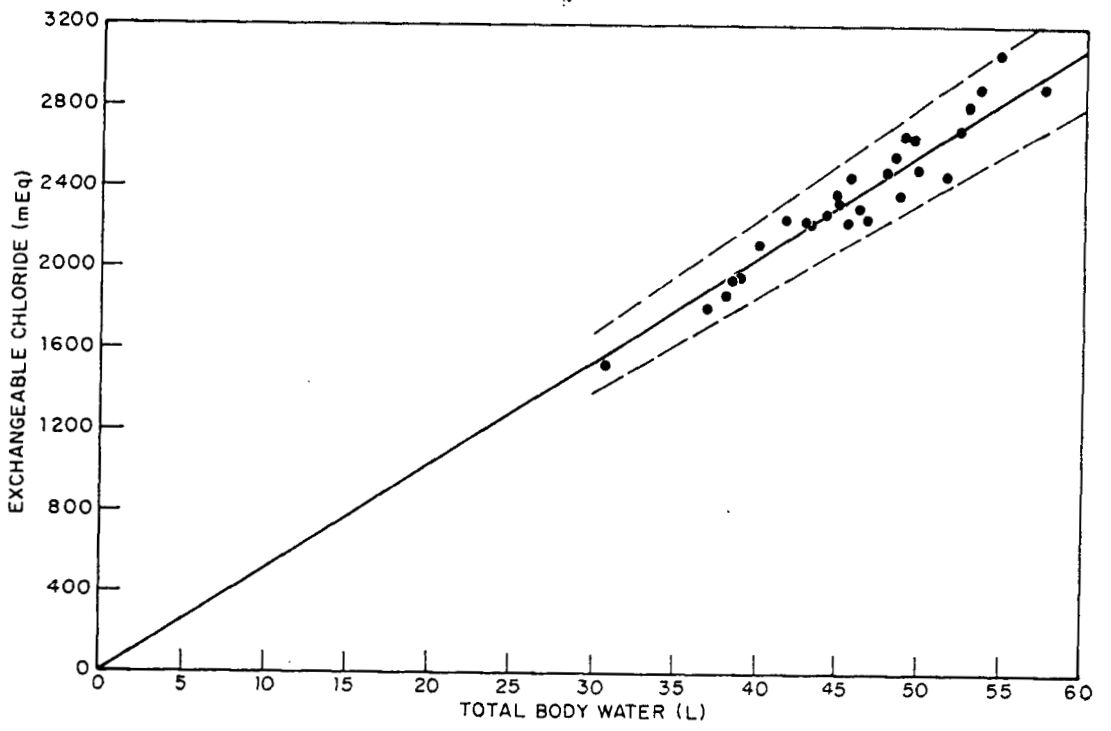


Fig. 5. Exchangeable chloride as a function of total body water. Cl_e is plotted on the ordinate. TBW is plotted on the abscissa. It is assumed that the regression passes through the origin. The regression line, $Cl_e = 51.4$ TBW, is shown (solid line) with its 95% confidence limits (broken lines).

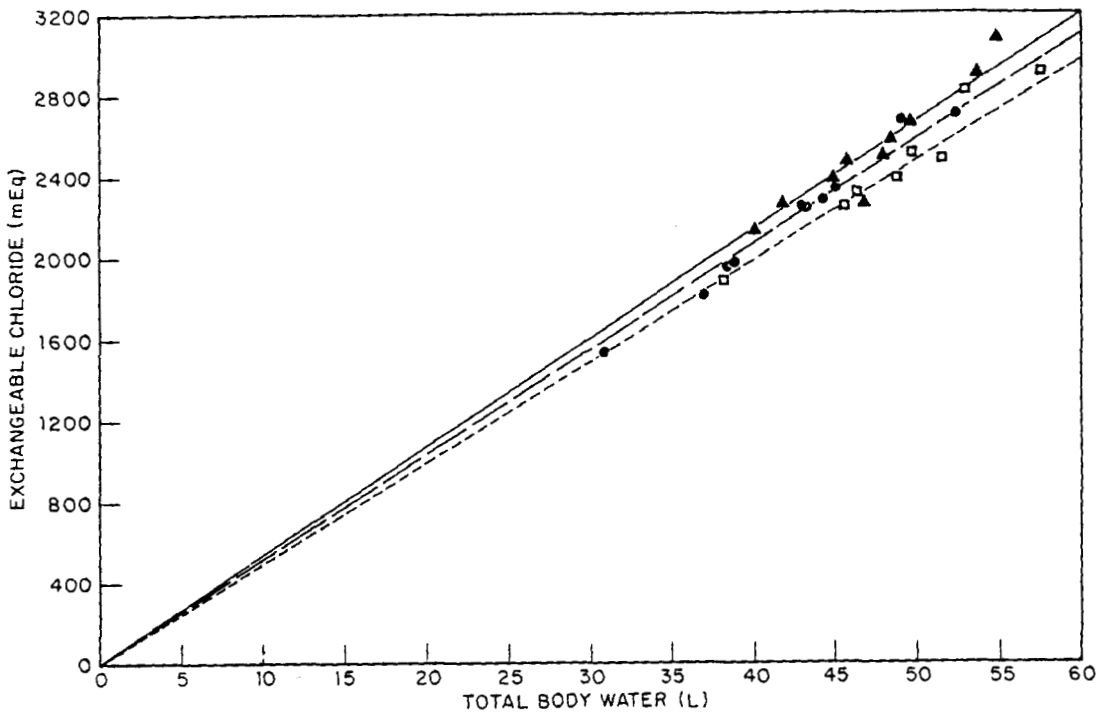


Fig. 6. Exchangeable chloride as a function of body water in men of varying degrees of fatness. Cl_e is plotted on the ordinate. TBW is plotted on the abscissa. The closed triangles represent those men who were less than 55% water, the solid line is the regression line for this group of data. The closed circles represent those men who were between 55% and 60% water. The long-dashed line is the regression line for this group of data. The open squares represent those men who were more than 60% water. The short-dashed line is the regression line for this group of data.

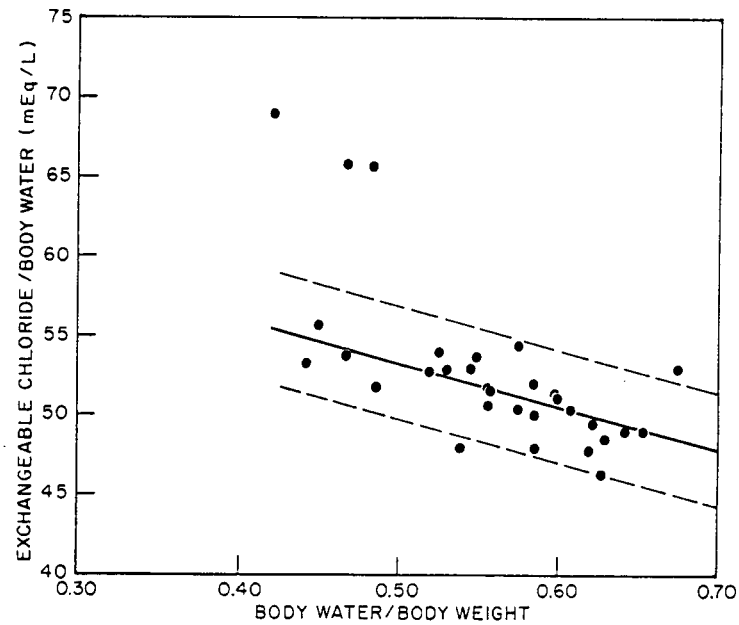


Fig. 7. Exchangeable chloride as a function of body water and body weight. Exchangeable chloride as mEq./liter of total body water, is plotted on the ordinate. Total body water, as TBW/body weight, is plotted on the abscissa. The regression line is shown (solid line) with its 95% confidence limits (broken lines). Three points which obviously fell outside the group were not included in the statistical evaluation.

Boling

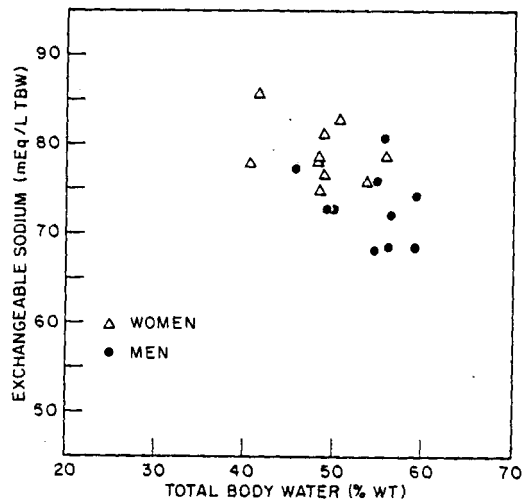


Fig. 8. Exchangeable sodium as a function of body water and body weight. Exchangeable sodium, as mEq./liter of total body water, is plotted on the ordinate. Total body water, as TBW/body weight, is plotted on the abscissa. The data are re-plotted from McMurrey et al. (6). 8

27

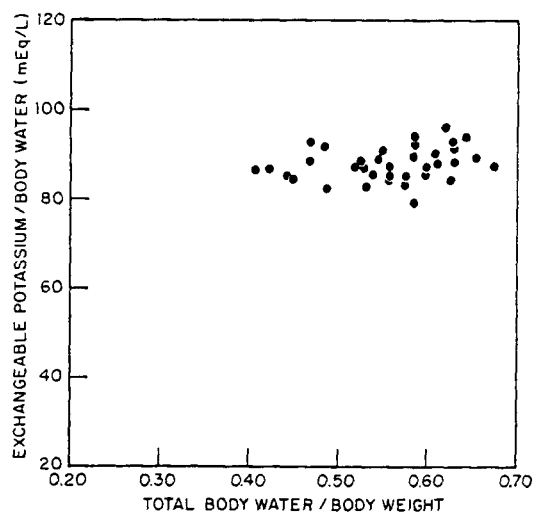


Fig. 9. Exchangeable potassium as a function of body water and body weight. Exchangeable potassium, as mEq./liter of total body water, is plotted on the ordinate. Total body water, as TBW/body weight, is plotted on the abscissa.

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