SUMMARY OF THE BASAL METABOLISM DATA ON 8,614 SUBJECTS WITH ESPECIAL REFERENCE TO THE NORMAL STANDARDS FOR THE ESTIMATION OF THE BASAL METABOLIC RATE.

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In the preceding paper we presented mathematical data which in our opinion indicate that the Du Bois normal standards based on calories for each square meter of body surface are the best so far advanced for predicting the basal heat production. We confirmed the previous observation of Du Bois that the height and weight factors as utilized by Harris and Benedict in their heat formulas predict the surface area in the average person with an approach to the same accuracy as the Du Bois height-weight formula. It was further pointed out that there was considerable discrepancy between the values for age and sex as assigned by Du Bois and by Harris and Benedict and that those adopted by the former were in better agreement with the evidence at present available.

The arguments advanced in that paper, however, need the support of further experimental evidence because, after all, standards cannot be maintained on mathematical considerations as opposed to experimental data. The object of this paper is to present in as brief a form as possible the basal metabolism data obtained in our laboratory from March, 1917, to January, 1922. During this time more than 25,000 basal metabolic rate determinations have been made on 8,614 subjects;[1] these results are

[1] Since going to press, an article by Means and Burgess has appeared (Means, J. H., and Burgess, H. W., *Arch. Int. Med.*, 1922, xxx, 507) in which they report metabolism studies on a series of 1,000 cases. Their data and conclusions are in accord with ours as to the clinical significance of alterations in the basal metabolic rate.

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TABLE I.*

Comparison of the Basal Metabolic Rate in 6,197 Patients with Thyroid Disorders.

Diagnosis.	Cases.	Percentage range.								
		Above + 20.	+ 20 to + 16	+ 20 to + 11	+ 15 to + 11	Normal + 10 to − 10.	− 11 to − 15	− 11 to − 20	− 16 to − 20	Below − 20.
		per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Exophthalmic goiter	2,569	93		5		2†				
Recurrent exophthalmic goiter‡	320	90	6		2	2				
Adenoma with hyperthyroidism	1,425	68		32§						
Recurrent adenoma with hyperthyroidism‡	46	57	17		26					
Adenoma without hyperthyroidism	1,111					100				
Recurrent adenoma without hyperthyroidism‡	62					90	8		2	
Colloid goiter‖	328		3		10	79	6		1	1
Myxedema	102							20		80
Postoperative myxedema	41							46		54
Questionable hypothyroidism	86					9		61		30
Cretinism¶	28					21		32		47
Thyroiditis	34	32		12		35		12		9
Malignant thyroid	45	22		9		67				2
Total No. of cases	6,197									

* The 8,614 cases summarized in Tables I and II represent all patients on whom tests were made from March, 1917 to January, 1922 with the exception of 87 in which a positive diagnosis of the presence of hyperthyroidism was not reached. Two of the 87 patients had metabolic rates between −15 and −11 per cent; thirty-one between −10 and +10 per cent; thirty-five between +11 and +20 per cent; and nineteen above +20 per cent. About one-half of this group had but one metabolic rate determination.

In a consideration of the significance of Tables I and II, the probability of errors in the determination of the basal metabolic rate must be evaluated. We estimate that in routine work in our laboratory there is a material error in about 1 per cent of the determinations and in an additional 5 per cent

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summarized in Tables I and II, and a few illustrative charts are given. The outstanding fact is that 77 per cent of all patients other than those with disorders of the thyroid had basal metabolic rates within the restricted Du Bois normal limits of +10 to −10 per cent; 90 per cent had basal metabolic rates within +15 to −15 per cent. The high percentage of normal results is most significant when it is considered that all, except 127 of the subjects who comprise our normal group, had a functional or organic disease.

Tables I and II include all patients on whom tests were made except the 87 referred to in the asterisk (*) footnote to Table I.

of the tests slight errors occur, the result of which is to place the patient either in the next higher or lower group, as arranged in the table. In about one-third of the patients with thyroid disorders only one determination was made and approximately one-half the patients who had other diseases, not involving the thyroid, had only one rate.

If in any group 100 typical cases with unquestioned diagnosis are selected and on whom sufficient basal metabolic rate determinations are made so that all errors are excluded, such a series will usually show a 99 per cent agreement with the characteristic metabolism for that condition.

† With a few exceptions the patients with exophthalmic goiter having basal metabolic rates below +20 per cent came under our observation during a period of remission.

‡ The patients listed under recurrent exophthalmic goiter and recurrent adenoma, with and without hyperthyroidism, include those who had had a previous partial thyroidectomy before any metabolism studies had been made in our laboratory and in whom the question of the necessity for further operative treatment was under consideration.

§ A basal metabolic rate of +10 per cent has been taken arbitrarily as dividing patients with adenomatous goiter into the groups with and without hyperthyroidism. While all cases with basal metabolic rates below +10 per cent are unquestionably not hyperthyroid, it cannot be assumed that all those with basal metabolic rates slightly above +10 per cent are necessarily hyperthyroid; unfortunately this group when tabulated was not subdivided at +15 per cent as was done in some of the other groups.

‖ The cases grouped in the table under colloid goiter include a considerable and unknown proportion of cases of colloid adenoma because in the earlier cases of the series less attention was directed to making a correct differential diagnosis than is at present exercised.

¶ Only rarely does a cretin come under our observation who has not had thyroid medication; therefore the results presented in the table cannot be considered as the average of a group of untreated cases. Furthermore, the normal standards for children are not yet as accurately established as are those for adults.

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TABLE II.

The Basal Metabolic Rate in Conditions Not Due to Thyroid Disorders.

Diagnosis.	Cases.	Percentage range.							
		Below − 20.	− 20 to − 16	− 15 to − 11	− 10 to + 10	+ 11 to + 15	+ 16 to + 20	Above + 20.	− 15 to + 15
		per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Normals	127			3.2	92.1	4.0	0.7		99.3
Migraine	31			6.4	93.6				100.0
Chronic nervous exhaustion.	267		1.2	2.3	87.3	8.6	0.7		98.2
Neurasthenia	384		0.3	3.6	84.3	9.4	1.4	1.0	97.3
Obesity	94	1.1	3.2	6.4	80.7	7.5	1.1		94.6
Asthenia	36		2.7	11.2	77.8	8.3			97.3
Essential hypertension	170			0.6	73.0	15.8	7.2	3.4	89.4
Cardiac neurosis	99		1.0	2.0	83.9	10.1	1.0	2.0	96.0
Heart block	10				80.0	10.0		10.0	90.0
Endocarditis	56			1.8	80.4	5.4	1.8	10.6	87.6
Myocarditis	55	1.8		3.6	81.9	10.9		1.8	96.4
Pericarditis	4				100.0				100.0
Congenital heart	5				80.0	20.0			100.0
Renal	127	4.0	1.6	3.2	72.4	12.6	4.0	2.4	88.2
Hodgkin's disease	1							100.0	
Mental	34	3.0	3.0	8.9	61.7	17.6	2.9	2.9	88.2
Epilepsy	22	9.1	4.6	9.1	77.3				86.4
Gastrointestinal	98	1.0	1.0	3.1	85.7	4.1	5.1		92.9
Gynecological	96	1.0	2.1	6.3	81.3	4.1	5.2		91.7
Malignancy	0		5.0		55.0	10.0	10.0	20.0	65.0
Dermatological	43	2.3		14.0	79.1	4.6			97.7
Pregnancy	30				70.0	10.0	10.0	10.0	80.0
Encephalitis	10			10.0	70.0			20.0	80.0
Dysphagia	65	16.9	6.2	10.7	63.1	3.1			76.9
Acromegaly	30	3.3		3.3	43.4	13.3	10.0	26.7	60.0
Hypopituitarism	58	12.1	25.9	15.5	34.5	5.2	3.4	3.4	55.2
Paget's disease	6				66.7	16.7		16.6	83.4
Addison's disease	13	15.4		7.7	69.2			7.7	76.9
Polycythemia	2				50.0			50.0	50.0
Secondary anemia	30		3.3		80.0	13.4		3.3	93.4
Anemia, splenic and pernicious	19			15.9	63.0	10.5		10.6	89.4
Leucemia, lymphatic and myelogenous	16				6.3	6.3		87.5	12.6
Questionable ductless glands.	24	8.3	8.3	16.6	58.4			8.4	75.0
Sclerosis of central nervous system; tabes	20				90.0	10.0			100.0
Diabetes	68	17.7	10.3	7.3	52.9		5.9	5.9	60.2
Arthritis	69	2.8	2.8	5.7	75.3	11.6	1.4		92.6
Miscellaneous, not thyroid..	178		2.7	5.6	77.1	8.4	4.0	2.2	91.1
Total No. of cases	2,417	2.1	2.2	4.6	77.1	8.3	2.6	3.1	90.0

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In Table I are tabulated the basal metabolic rate findings in diseases of the thyroid and in Table II of all conditions other than of the thyroid, including such diseases as the leucemias which are characterized by abnormal basal metabolic rates. A study of these tables reveals most convincing evidence that the basal metabolic rate is characteristically normal in all except a few specific diseases.

In our laboratory, metabolic rates are obtained by the open or gasometer method with analysis of the expired air by the Haldane gas analysis apparatus. Original readings are made in duplicate by two observers. Two analyses are made of the expired air, and the results are accepted if they agree within 0.04 per cent for carbon dioxide and 0.06 per cent for oxygen; additional analyses are required if there is a greater discrepancy. The calculations are made by four place logarithms and checked by the nomographic chart method. Repeated outdoor air analyses, of which permanent records are kept, are made at stated intervals with each Haldane apparatus and by each analyst; similarly, analyses of a common sample of expired air are frequently made by all analysts. A very definite routine, described in detail in our laboratory manual has been adopted with the intent of reducing technical errors to a minimum. As a result we feel that accidental technical errors except those due to loss of expired air from an improper application of the face mask are of very rare occurrence. A material error from the cause mentioned occurs in approximately 1 per cent of the tests and always causes a lowering of the metabolic rate.

Technical errors are, however, a much less common source of inaccuracy than failure to obtain the metabolic rate under absolute *basal* conditions. A *basal* determination is not obtained if the subjects fail to cooperate, or are nervous and worried over the procedure as they are apt to be in the first test. Under such conditions the observed metabolic rate may be from 5 to 30 per cent too high. Therefore, a first test with an observed metabolic rate between +10 and +20 per cent will probably be lowered to within the normal limits of variation if the test is repeated a sufficient number of times to obtain a true basal metabolic rate. In the various groups reported in Table II, in which there are a few slightly elevated rates, experience has convinced us that

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nearly all would have been normal if a sufficient number of tests had been made on those subjects to eliminate temporary (non-basal) elevations. These temporary elevations of the metabolic rate are, in clinical work by far the most confusing factor in the estimation of the significance of the basal metabolic rate and are of great importance in the consideration of data such as are presented in this paper. Nothing the subject does or fails to do, except deep sleep, can depress the metabolic rate, whereas any slight disturbing condition such as a headache, pain, discomfort, excitement, restless or uneasy sleep the preceding night, fear, movements, fever, surreptitious ingestion of food, or innumerable other factors may, in certain cases, cause an appreciable elevation.

The cause of the temporary elevation in the metabolic rate is not definitely known aside from that due to fever, food, and muscular movement. Aub has pointed out that with the exception of the thyroid and adrenal glands there is at present no evidence that any other ductless gland produces a demonstrable calorigenic reaction. Plummer and Boothby have shown that these rapid fluctuations in the metabolic rate cannot be accounted for in man by corresponding variations in the thyroxin concentration in the tissues because the maximum effect of a single intravenous dose of 10 mg. of thyroxin is not usually reached until between the 5th and 10th day after administration and it takes as a rule several weeks for the reaction entirely to disappear. In some instances these temporary elevations are probably due, as suggested by Aub, to the emotional stimulation of the adrenal glands resulting in a discharge into the circulation of an excess of adrenalin secretion. This explanation is in accordance with our observations as we have shown that adrenalin, when injected into dogs in quantities within the accepted power of the adrenal glands to secrete, produces a definite calorigenic reaction; the alteration in heat production under such conditions is an increase of from about 5 to 20 per cent, which is of the same average order of magnitude and duration noted in these temporary elevations met with occasionally in clinical work. Elevations of this type in the observed rate must be carefully differentiated from true elevations of the *basal* metabolic rate.

In Chart 1 are plotted the basal metabolic rates, computed from the Du Bois surface area standards, obtained on 127 subjects whom we consider "normal" because they had passed through a

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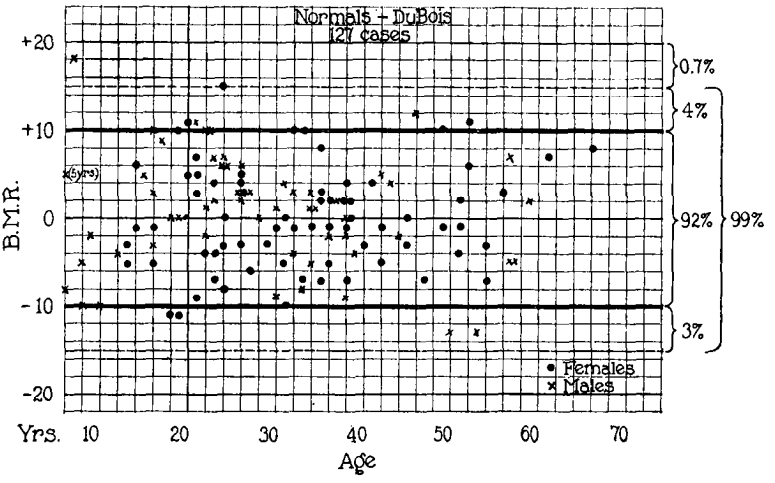

CHART 1.

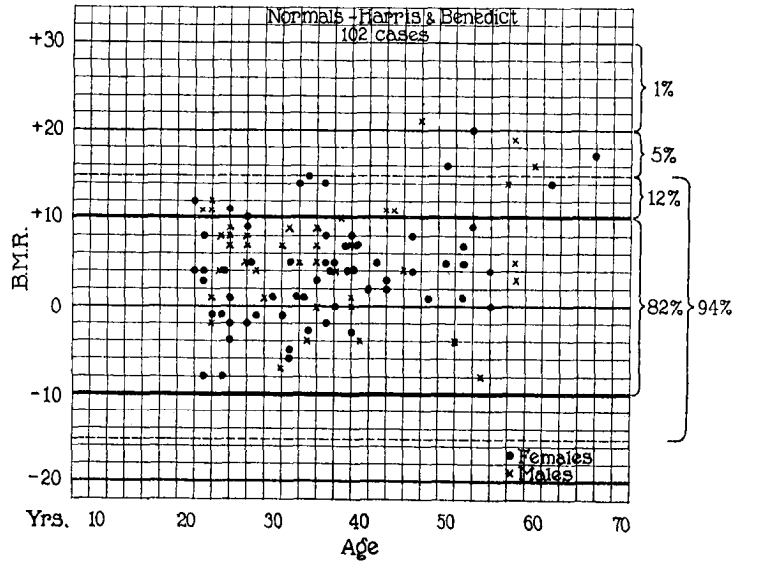

CHART 2.

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careful clinical examination without revealing any evidence of disease that could in any way affect their metabolism. The criticism that these subjects were practically all "patients" and came for examination because they thought they were, or might be, ill is effectively offset by this careful negative examination; several of the subjects had bad teeth, tonsils, a hernia, or other mechanical fault, all of which, as is recognized, could in no way affect the metabolism. Of the 127 subjects plotted on the chart, 109 had only one metabolic rate determination; none of those with results between +11 and +15 per cent or between −11 and −15 per cent, and only eighteen of those between +10 and −10 per cent had more than a single test. In Chart 2 are plotted the basal metabolic rates, computed from the Harris and Benedict standards, of the 102 subjects in Chart 1 who are 21 years, or more, or age.

In Table III are given the essential data with regard to this group of 102 normal subjects who are 21 years, or more, of age. The most interesting evidence in this table is the fact that the surface areas agree in most instances within 1 per cent, as calculated by the Du Bois height-weight formula and by the Harris and Benedict formulas derived according to the method given in the preceding paper; in only one case does the surface area as calculated by the two methods differ by as much as 5 per cent. The variations in the height-weight factors are in all cases so slight that the maximal alteration in the metabolic rate from the difference in value of these factors expressed as surface area is never more than 6 points from that calculated by the Du Bois height-weight factors for surface area, and is usually very much less. On the other hand, considerable variation is caused in many instances by the difference in value between the two standards for the factors of age and sex. These variations in the age and sex factors develop differences of at least 5 and possibly 14 points in the basal metabolic rate in a considerable proportion of the cases. The basal metabolic rates, as calculated by both methods, however, are in agreement when there is a cancellation of the variations of height and weight by the age and sex factors, or when all factors of both methods are of practically equal value.

We have also calculated a table similar to Table III, using the data reported by Harris and Benedict (their Tables C and D) for their 136 normal men and 103 normal women. The calcu-

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TABLE III.

Essential Data on 102 Normal Persons.

No.	Sex.	Age.	Height.	Weight.	Calories for each 24 hrs.	Surface area.		Basal metabolic rate.	
						Du Bois* height-weight formula.	Harris and Benedict formula.	Du Bois standards.	Harris and Benedict standards.
			cm.	*kg.*		*sq. m.*	*sq. m.*	*per cent*	*per cent*
1	F.	21	156.5	55.6	1,435	1.54	1.55	+5	+4
2	"	21	164.5	48.0	1,483	1.50	1.49	+11	+12
3	"	22	162.0	64.6	1,354	1.68	1.66	−9	−8
4	"	22	153.5	47.0	1,330	1.42	1.45	+5	+3
5	"	22	160.6	73.9	1,612	1.77	1.76	+3	+4
6	"	22	159.5	51.2	1,439	1.51	1.51	+7	+8
7	"	23	170.0	56.1	1,390	1.64	1.59	−4	−1
8	"	24	166.7	83.9	1,641	1.93	1.88	−4	−1
9	"	24	157.9	57.7	1,274	1.57	1.58	−8	−8
10	"	24	155.5	67.2	1,529	1.66	1.68	+4	+4
11	"	25	161.9	46.5	1,294	1.46	1.47	0	+1
12	"	25	154.6	37.0	1,303	1.28	1.35	+15	+11
13	"	25	158.6	69.1	1,461	1.70	1.70	−3	−2
14	"	25	165.6	57.5	1,342	1.64	1.59	−8	−4
15	"	27	164.0	45.6	1,330	1.46	1.46	+3	+5
16	"	27	167.5	60.0	1,551	1.66	1.62	+5	+10
17	"	27	168.5	65.3	1,598	1.73	1.68	+4	+9
18	"	27	154.4	67.5	1,434	1.66	1.68	−3	−2
19	"	28	163.7	68.6	1,461	1.75	1.71	−6	−1
20	"	30	164.4	66.1	1,466	1.72	1.68	−3	+1
21	"	31	155.5	66.8	1,428	1.65	1.67	−1	−1
22	"	32	163.9	54.8	1,248	1.58	1.56	−10	−6
23	"	32	166.3	55.0	1,410	1.61	1.57	0	+5
24	"	32	152.0	49.0	1,191	1.43	1.47	−5	−5
25	"	33	161.1	49.5	1,450	1.50	1.50	+10	+14
26	"	33	164.9	69.8	1,485	1.77	1.72	−4	+1
27	"	33	157.0	45.3	1,233	1.42	1.44	−1	+1
28	"	34	165.0	52.8	1,500	1.56	1.54	+10	+15
29	"	34	161.6	69.2	1,417	1.73	1.71	−7	−3
30	"	35	162.0	53.4	1,343	1.55	1.54	−1	+3
31	"	36	153.9	63.8	1,448	1.61	1.64	+3	+5
32	"	36	161.1	56.3	1,295	1.58	1.57	−7	−2
33	"	36	163.0	64.0	1,597	1.68	1.66	+8	+14
34	"	36	172.0	92.1	1,818	2.04	1.98	+2	+8
35	"	37	160.6	61.7	1,367	1.64	1.63	−5	0

* The Du Bois surface area is obtained by using a nomographic chart and, therefore, may vary from a mathematically calculated area by approximately 1 per cent.

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TABLE III—*Continued.*

No.	Sex.	Age.	Height.	Weight.	Calories for each 24 hrs.	Surface area.		Basal metabolic rate.	
						Du Bois height-weight formula.	Harris and Benedict formula.	Du Bois standards.	Harris and Benedict standards.
			cm.	*kg.*		*sq. m.*	*sq. m.*	*per cent*	*per cent*
36	F.	37	156.0	46.2	1,264	1.42	1.45	+2	+4
37	"	37	167.5	56.9	1,408	1.63	1.59	−1	+5
38	"	39	160.0	59.3	1,386	1.60	1.60	−1	+4
39	"	39	160.1	64.4	1,493	1.67	1.65	+2	+8
40	"	39	154.5	60.6	1,302	1.59	1.60	−7	−3
41	"	39	159.8	55.1	1,382	1.55	1.55	+2	+7
42	"	39	154.5	55.0	1,377	1.52	1.54	+4	+7
43	"	39	153.0	55.5	1,333	1.52	1.54	0	+4
44	"	41	165.1	61.8	1,386	1.66	1.64	−3	+2
45	"	42	151.8	76.5	1,552	1.73	1.77	+4	+5
46	"	43	176.6	92.2	1,712	2.08	1.99	−5	+3
47	"	43	153.5	49.4	1,239	1.45	1.48	−1	+2
48	"	46	163.3	64.9	1,467	1.70	1.67	0	+8
49	"	46	168.7	86.9	1,651	1.97	1.92	−3	+4
50	"	48	163.8	68.0	1,401	1.74	1.70	−7	+1
51	"	50	165.8	74.5	1,512	1.82	1.78	−1	+5
52	"	50	160.0	52.7	1,411	1.53	1.53	+10	+16
53	"	52	165.5	90.0	1,601	1.98	1.94	−4	+1
54	"	52	159.0	73.3	1,510	1.76	1.75	+2	+7
55	"	52	162.0	44.7	1,197	1.44	1.45	−1	+5
56	"	53	151.0	51.7	1,289	1.45	1.50	+6	+9
57	"	53	165.7	47.4	1,397	1.50	1.48	+11	+20
58	"	55	160.3	46.4	1,136	1.46	1.46	−7	0
59	"	55	166.2	67.0	1,402	1.73	1.70	−3	+4
60	"	62	158.5	47.3	1,267	1.45	1.47	+7	+14
61	"	67	154.1	45.9	1,246	1.41	1.44	+8	+17
62	M.	22	168.3	66.3	1,849	1.76	1.76	+11	+11
63	"	23	173.1	61.9	1,822	1.74	1.73	+10	+12
64	"	23	177.7	76.9	1,860	1.95	1.97	+1	+1
65	"	23	168.7	67.6	1,647	1.77	1.79	−2	−2
66	"	23	180.0	64.6	1,894	1.82	1.80	+10	+11
67	"	24	168.9	59.2	1,688	1.67	1.67	+7	+8
68	"	24	172.0	54.2	1,570	1.63	1.61	+2	+4
69	"	25	171.0	58.0	1,692	1.68	1.66	+6	+9
70	"	25	180.2	75.8	1,963	1.96	1.96	+6	+7
71	"	25	178.3	70.5	1,904	1.88	1.88	+7	+8
72	"	27	165.0	61.3	1,664	1.66	1.68	+6	+7

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TABLE III—*Concluded.*

No.	Sex.	Age.	Height.	Weight.	Calories for each 24 hrs.	Surface area.		Basal metabolic rate.	
						Du Bois height-weight formula.	Harris and Benedict formula.	Du Bois standards.	Harris and Benedict standards.
			cm.	*kg.*		*sq. m.*	*sq. m.*	*per cent*	*per cent*
73	M.	27	173.4	56.7	1,644	1.68	1.65	+3	+8
74	"	27	171.0	62.0	1,675	1.73	1.72	+2	+5
75	"	28	171.8	70.4	1,773	1.81	1.85	+3	+4
76	"	29	161.3	64.9	1,588	1.67	1.71	0	+1
77	"	31	167.6	57.8	1,595	1.66	1.64	+1	+7
78	"	31	169.0	68.2	1,524	1.77	1.80	−9	−7
79	"	32	170.9	60.8	1,679	1.71	1.70	+4	+9
80	"	33	162.5	68.0	1,680	1.72	1.76	+3	+5
81	"	34	177.7	66.9	1,588	1.83	1.83	−8	−4
82	"	35	175.0	61.0	1,656	1.73	1.72	+1	+7
83	"	35	173.2	66.0	1,745	1.79	1.79	+3	+9
84	"	35	172.2	70.5	1,748	1.82	1.85	+1	+5
85	"	35	173.1	70.4	1,658	1.84	1.85	−5	0
86	"	37	172.9	67.8	1,680	1.81	1.81	−2	+4
87	"	38	164.0	54.6	1,524	1.58	1.57	+2	+10
88	"	39	170.0	82.0	1,776	1.92	2.00	−2	0
89	"	39	172.0	51.8	1,382	1.60	1.58	−9	+1
90	"	39	180.8	72.7	1,827	1.92	1.93	0	+7
91	"	40	180.0	89.9	1,854	2.09	2.17	−4	−4
92	"	43	172.3	70.2	1,773	1.83	1.84	+5	+11
93	"	44	181.0	71.3	1,830	1.91	1.91	+4	+11
94	"	45	167.1	67.5	1,593	1.75	1.78	−2	+4
95	"	47	175.0	68.8	1,908	1.84	1.84	+12	+21
96	"	51	177.4	62.0	1,404	1.78	1.75	−13	−4
97	"	54	178.4	78.8	1,535	1.97	2.00	−13	−8
98	"	57	182.6	67.0	1,730	1.87	1.85	+3	+14
99	"	58	169.0	58.2	1,393	1.65	1.65	−6	+5
100	"	58	154.3	60.8	1,526	1.58	1.61	+7	+19
101	"	58	179.0	78.0	1,690	1.97	1.99	−5	+3
102	"	60	169.5	53.2	1,445	1.61	1.59	+2	+16

lation of the surface area by the formulas derived from the Harris and Benedict heat prediction formulas gives on their own subjects a figure almost identical with the surface area obtained by the Du Bois height-weight formula. Space prevents the reproduction of this table but it can be summarized as follows:

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The average surface area for the 136 normal men according to the Du Bois height-weight factors is 1.76 square meters and according to the Harris and Benedict height-weight factors for men is also 1.76 square meters; for the 103 normal women the Du Bois factors give an average of 1.59 square meters and the Harris and Benedict factors for women, 1.57 square meters; the

TABLE IV.

Summary by Decades of the Essential Data on 102 Normal Persons.

Decade.	Total No. of cases.	Height.	Weight.	Surface area.		Basal metabolic rate.	
				Du Bois.	Harris and Benedict.	Du Bois.	Harris and Benedict.
Females.							
		cm.	*kg.*	*sq. m.*	*sq. m.*	*per cent*	*per cent*
21–29	19	161.3	59.1	1.61	1.60	+0.9	+2.3
30–39	24	160.5	59.3	1.61	1.60	−0.4	+3.6
40–49	7	163.4	71.4	1.76	1.74	−2.1	+3.6
50–59	9	161.8	60.9	1.63	1.62	+1.4	+7.4
60–69	2	156.5	46.6	1.43	1.46	+7.5	+15.5
Average	61	161.2	60.4	1.62	1.61	+0.3	+4.2
Males.							
21–29	15	172.0	64.7	1.76	1.76	+4.8	+6.3
30–39	14	171.6	65.6	1.76	1.77	−1.4	+3.8
40–49	5	175.0	73.5	1.88	1.91	+3.0	+8.6
50–59	6	173.5	67.5	1.80	1.81	−4.5	+4.8
60–69	1	169.5	53.2	1.61	1.59	+2.0	+16.0
Average	41	172.4	66.2	1.78	1.79	+1.0	+5.7
Average for males and females	102	165.7	62.8	1.69	1.68	+0.6	+4.8

individual variations are of approximately the same order of magnitude as shown in our own series given in Table III.

In Table IV is given the grand average of the 102 normal persons, and the average for each decade according to sex. The average surface area for the entire group calculated by the Du Bois height-weight formula is 1.69 square meters and by the

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Harris and Benedict factors, 1.68 square meters, a negligible variation of 0.6 per cent. The average basal metabolic rate by the Du Bois method is +0.6 per cent and by the Harris and Benedict +4.8 per cent, again showing that the main variation in the results is due to a discrepancy in the age-sex factors and not to a fundamental disagreement in the values for the factors of height and weight.

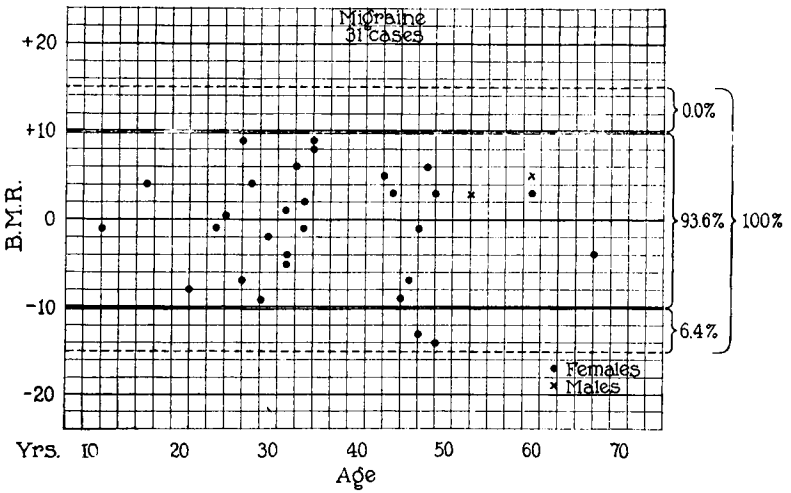

CHART 3.

On Chart 3 are plotted the basal metabolic rates according to the Du Bois method for thirty-one patients who had severe migraine, but were otherwise entirely normal. It shows an even better percentage of cases falling within the Du Bois limits of normality and only eight had more than one rate. On Chart 4 are plotted the basal metabolic rates of 267 patients with chronic nervous exhaustion, and on Chart 5 the rates of 384 patients with neurasthenia. These two groups are essentially similar, as some of our clinicians prefer one term and some the other, although as a rule under the latter term are included the more easily excitable patients. This difference in temperament is illustrated by the tendency for the first metabolism test to be slightly higher in the latter group; only about one-fourth of these patients had

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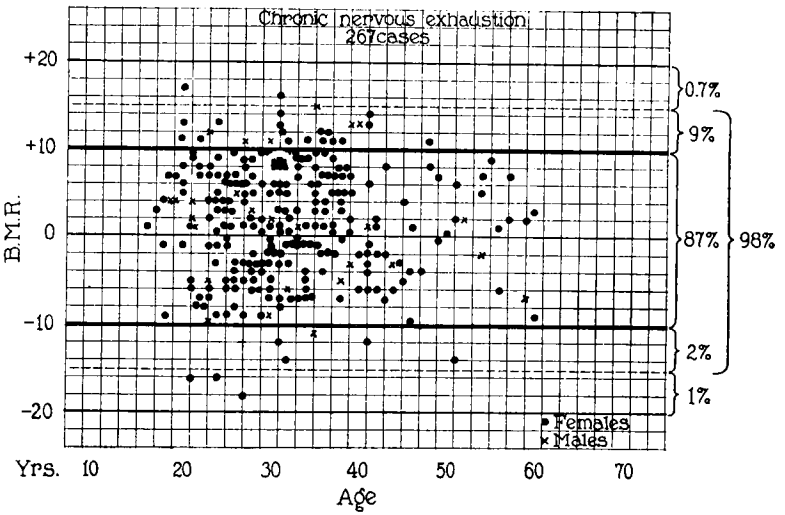

CHART 4.

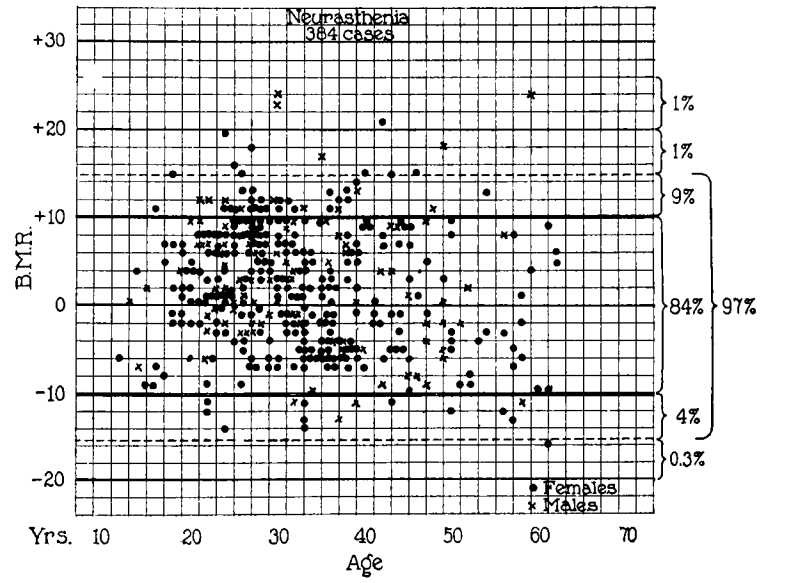

CHART 5.

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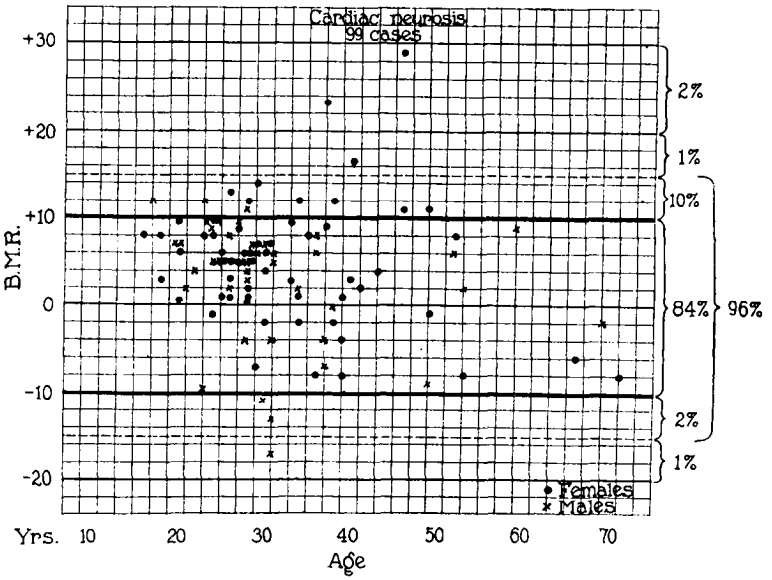

Chart 6.

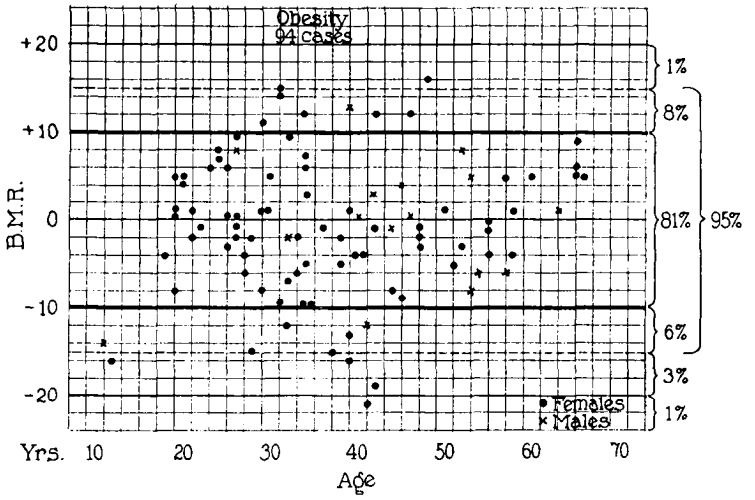

Chart 7.

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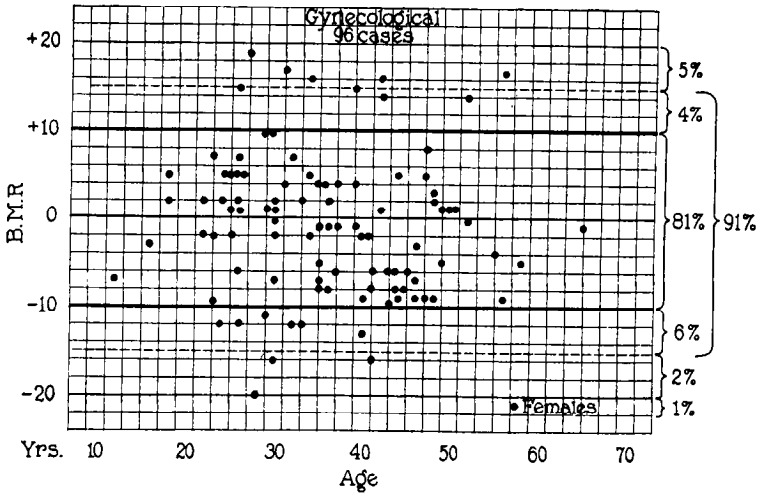

CHART 8.

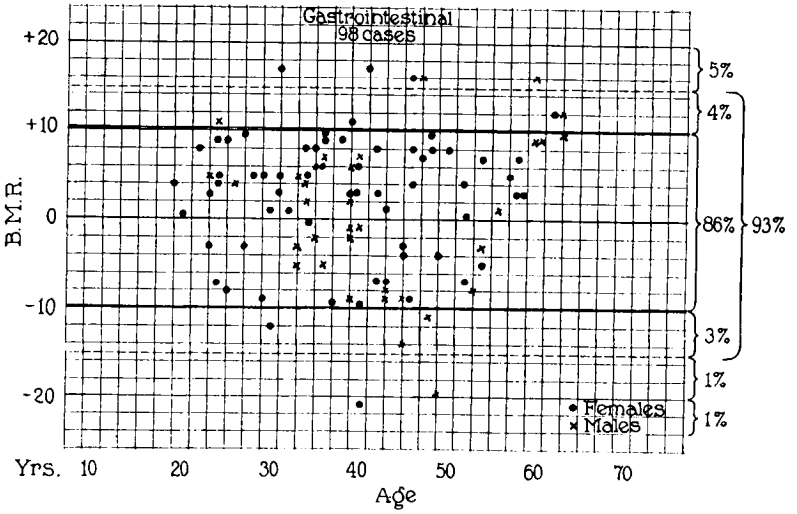

CHART 9.

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more than one rate. Chart 6 illustrates the tendency of a single clinical determination in certain persons with cardiac neurosis to be above the present Du Bois normal standards, while the rates in obesity, as shown in Chart 7, show an opposite tendency. Charts 8 and 9 serve to illustrate the metabolic rate findings in patients with gynecologic and gastrointestinal diseases.

TABLE V.

Comparison of the Surface Area and Basal Metabolism as Calculated by the Du Bois and by the Harris and Benedict Methods in 455 Persons.

Sex.	Total No. of cases.	Height.	Weight.	Surface area.		Basal metabolic rate.	
				Du Bois.	Harris and Benedict.	Du Bois.	Harris and Benedict.
Chronic nervous exhaustion.							
		cm.	*kg.*	*sq. m.*	*sq. m.*	*per cent*	*per cent*
Females	222	162.4	53.8	1.56	1.55	+1.2	+5.0
Males	27	172.6	60.6	1.71	1.71	+1.0	+5.7
" and females	249	163.5	54.6	1.57	1.56	+1.2	+5.1
Migraine.							
Females	27	161.3	55.2	1.56	1.56	−1.0	+3.1
Males	2	174.0	66.0	1.79	1.79	+3.5	+12.5
" and females	29	162.1	56.0	1.58	1.57	−0.7	+3.8
Obesity.							
Females	61	161.9	96.1	1.99	2.00	−0.8	+1.5
Males	12	173.3	105.3	2.17	2.36	+0.1	−3.9
" and females	73	163.7	97.6	2.02	2.06	−0.7	+0.5
Normals.							
Females	61	161.2	60.4	1.62	1.61	+0.3	+4.2
Males	41	172.4	66.2	1.78	1.79	+1.0	+5.7
" and females	102	165.7	62.8	1.69	1.68	+0.6	+4.8

Tables similar to Tables III and IV have been made for the cases of chronic nervous exhaustion (249), migraine (twenty-nine), and uncomplicated obesity (73) that fall within the limits of the Harris and Benedict tables. It is impracticable to publish these in full; therefore, only the averages for the males and females are given in Table V. The surface area for any group is almost

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TABLE VI.

Comparison of the Basal Metabolic Rate as Calculated by the Du Bois and by the Harris and Benedict Methods in 455 Persons.

		Total cases.	Percentage range.											
			Below − 20.	− 20 to − 16	− 15 to − 11	− 10 to − 6	− 5 to + 5	+ 6 to + 10	+ 11 to + 15	+ 16 to + 20	Above + 20.	− 10 to + 10	− 15 to + 15
Chronic nervous exhaustion.													
			per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Du Bois.	Female	222		1	3	13	52	23	7	0.5		88	98
	Male	27			7	15	52	7	19			74	100
	" and female	249		1	4	13	52	21	8	0.4		87	98
Harris and Benedict.	Female	222		0.5	2	5	45	25	17	5	1	74	93
	Male	27				11	26	33	22	7		70	93
	" and female	249		0.4	2	6	43	26	18	6	1	74	93
Migraine.													
Du Bois.	Female	27			7	19	56	19				93	100
	Male	2					100					100	100
	" and female	29			7	17	59	17				93	100
Harris and Benedict.	Female	27				15	52	19	15			85	100
	Male	2							100			0	100
	" and female	29				14	48	17	21			79	100
Obesity.													
Du Bois.	Female	61	2	3	7	11	52	16	8			80	95
	Male	12			8	25	50	8	8			83	100
	" and female	73	1	3	7	14	52	15	8			81	96
Harris and Benedict.	Female	61		2	8	8	46	20	15	2		74	97
	Male	12			17	17	58	8				83	100
	" and female	73		1	10	10	48	18	12	1		75	97
Normals.													
Du Bois.	Female	61				16	66	13	5			95	100
	Male	41			5	10	61	19	5			90	100
	" and female	102			2	14	64	16	5			93	100
Harris and Benedict.	Female	61				5	64	16	10	5		85	95
	Male	41				5	44	29	15	5	2	78	93
	" and female	102				5	56	22	12	5	1	82	94

In the calculations the percentages were carried to two decimal places.

In the table the nearest round numbers have been used, thus explaining apparent slight discrepancies in the addition of the percentages.

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identical, whether calculated by the Harris and Benedict or the Du Bois formula. The least variation in the basal metabolic rate is in the group of obese persons, because, as shown in the previous paper, the age and sex factors of Du Bois and of Harris and Benedict are in much closer agreement for large than for small subjects. In Table VI are given the percentages of subjects who have basal metabolic rates within certain ranges as calculated by the Du Bois and by the Harris and Benedict methods. A study of this table reveals the fact that the basal metabolic rates, as calculated by the Du Bois method, are more often between −5 and +5 per cent, between −10 and +10 per cent, and between − 15 and + 15 per cent than by the Harris and Benedict method.

As we have said, if repeated tests were made a considerable number of the determinations plotted in the charts above the zero line would be from 1 to 5 points lower; while a smaller proportion of those below that line would be lowered but less on the average. There is some evidence to indicate that possibly the absolute level of the Du Bois age and sex standards is slightly too high; however, at the present time there are not sufficient data available to warrant their alteration. In our opinion the correlation study of Harris and Benedict has confirmed the accuracy of the Du Bois height-weight factors independently of any theoretic considerations with regard to surface area so that the next improvement to be anticipated is in the age-sex factors.

SUMMARY.

The charts and tables show the high percentage of persons who have normal basal metabolic rates according to the Du Bois standards, unless they are suffering from some specific disease characterized by an alteration in the basal metabolism. The limitations of the basal metabolic rate as a diagnostic aid can likewise be evaluated. As the clinical significance of abnormal basal metabolic rates will be treated in detail in other publications, we shall not here discuss this phase of the subject, except to point out that the data here presented are evidence to the effect that the basal metabolic rate differentiates diseases into those with increased, normal, and decreased metabolism as sharply as the temperature divides diseases into the febrile and afebrile groups.

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The two points we wish especially to emphasize are; first, that a high percentage of persons has a basal metabolic rate within ±10 per cent and a very high percentage within ±15 per cent of the Du Bois standards for age and sex for each square meter of body surface provided the subjects have no definite disease that is characterized by a pathologic alteration in the rate of heat production; and second, that a smaller percentage of these same subjects has basal metabolic rates within the same limits when the Harris and Benedict standards are used.

CONCLUSION.

The Du Bois normal standards for age and sex based on calories for each square meter of body surface determined by the Du Bois height-weight formula are the best standards at present available for the prediction of the normal heat production, as shown by a study of the basal metabolic rate of 8,614 persons.

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SUMMARY OF THE BASAL METABOLISM DATA ON 8,614 SUBJECTS WITH ESPECIAL REFERENCE TO THE NORMAL STANDARDS FOR THE ESTIMATION OF THE BASAL METABOLIC RATE

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