

BASAL METABOLISM OF FIFTY-FOUR FRESHMAN
WOMEN AT KANSAS STATE COLLEGE

by

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B. S., Kansas State Teachers College, Pittsburg, 1932

A THESIS

submitted in partial fulfillment of the

requirements for the degree of

MASTER OF SCIENCE

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1937

Spec
Coll 1878.72
LD 1100m
2668 737.
T4 25
1937
5515

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INTRODUCTION

At the present time there is wide-spread interest in the physical status of college women. Among other things, their basal metabolism has received considerable attention. Studies have been reported of the basal energy requirements of this group in various sections of the United States including northern, southern, eastern, and western states. Apparently no such studies have been made for the central region. It was, therefore, deemed desirable to determine the normal basal metabolic rate for a small group of Kansas college women and to compare the results with those of similar studies made in other states. Furthermore, it was believed that such a study would help to provide a much-needed standard adapted to this particular locality.

REVIEW OF LITERATURE

Although indebted to the English, French, and German schools for much of the early knowledge and experimentation concerning energy metabolism, American physiologists recently have made important contributions to this field.

Atwater and Benedict (1) presented accurate data on the energy metabolism of men who had lived and worked in their respiration calorimeter for days at a time. To Lusk (10), we are indebted for many valuable studies, among them the effects on metabolism of taking different kinds of food.

Benedict (2) made a series of studies on normal subjects which have served as a basis for standards. They also have developed a simple apparatus for the use of clinicians in hospital work by which basal metabolism may be readily determined. This followed the demonstration by Magnus-Levy in 1895 of an increase in the basal metabolic rate in the disease known as exophthalmic goiter (8). In order to use this means of diagnosis, a simple device for determining basal metabolism was imperative for use in clinics. Benedict's model has met this need and at the present time there are many of these machines in use.

Several workers in widely different parts of the United States have confined their efforts in the field of metabolism to investigations of the metabolic rate of young women between the ages of 16 and 25 years. They have attempted to determine the normal basal metabolism for this age-group and to determine some of the factors influencing it.

At Wellesley college in 1928, Benedict and Gustafson (3) made an important study on American women in educational institutions. Twenty subjects ranging in age from 18 to 21 years were given a basal metabolism test once a month between October, 1926 and January, 1928. The oxygen consumption of these women seemed to point strongly to the conclusion that basal metabolism tends to rise somewhat during spring and summer.

Two years later, McKay (12), in Ohio, using 96 young women from 14 to 24 years of age, studied the effects of various factors on basal metabolism. Upon 5 of her subjects, who were between the ages of 21 and 24 years, she was able to run repeated tests which showed that daily fluctuations were noticeable in basal metabolic rates of Ohio young women. At the same time, she confirmed the work of Benedict and Gustafson (3) in that she found the basal rate somewhat higher in the spring than in autumn or winter. McKay also had sufficient data on 15-, 16-, 17-, and 18-year old subjects to justify the conclusion that the basal metabolism of these age-groups, when actually measured, was lower than that predicted by the Aub-Du Bois standards. She agreed with earlier workers that age and surface area were a better means of prediction than weight.

or height.

In 1930, Tilt (19) reported her first study of basal metabolic rates of young women living in Florida. She used 52 subjects, all of whom were native Floridians or had lived most of their lives in that state. Within that group, 8 of the subjects indulged in greater physical activity than the others. Averaging the groups separately, she came to the conclusion that activity made very little difference in the basal rate since the average results for the more active group agreed closely with those obtained for the women indulging in less physical activity. Tilt found no seasonal variation in metabolic rates but the fact that there is little change in Florida seasons and that her group was small, may account for her results.

About the same time, 1931, Coons (6) reported a low basal metabolic rate for college women in Oklahoma when compared with the usual standards which have been regarded as normal. In a follow-up study, Coons and Schiefelbusch (7) considered basal metabolism findings chiefly in relation to whether the college women were under or overweight. Their work showed that the overweight woman tended to metabolize at a rate higher than normal and that the effects of undernutrition or overnutrition were manifest

even when the weight variations were slight. Du Bois (8) agrees with this statement when he says: "The lower averages for Oklahoma women may be influenced partly by the state of nutrition of the subjects." He further hints that the present day tendency toward lower food consumption may be contributing to the slightly low results for basal metabolism being reported for women.

In the second study, Coons and Schiefelbusch (7) found that the basal rates of 84 per cent of the underweight and overweight cases fell within the ± 10 per cent range considered normal by the Harris-Benedict standard. Ninety-four per cent fell within the ± 15 per cent range suggested by Coons and Schiefelbusch as normal for Oklahoma women on the basis of the average number of Calories per square meter of body surface. Du Bois (8), Blunt et al. (4), Lusk (10), McKay (12) and MacLeod (11) are fairly well agreed that persons of abnormal body build can be compared only on a basis of Calories per square meter of body surface.

Coons and Schiefelbusch (7) further found that, in general, there was a tendency toward a metabolism above normal in overweight and below normal in underweight subjects by every method of comparison used, including Cal-

ories per square meter of surface area and per unit of height or weight.

Remington and Culp (14), in 1931, made a study of the basal metabolism of medical students and nurses in training at Charleston, South Carolina. There were 93 student nurses included in the group. These subjects, while leading fairly active lives, showed an average metabolism about 10 per cent lower than that predicted by the Aub-Du Bois standards. It may be assumed that women have a lower basal metabolism than the accepted standards would indicate as, in this investigation, climate, dietary habits, and the state of nutrition were not considered responsible for the low values obtained. These workers also considered the possible effects of the iodine present in that section of the country but felt that it did not change the basal rates.

Stark (15), at the University of Wisconsin in 1933, used college women 17 to 21 years of age in an attempt to determine standards suitable for practical use with Wisconsin students. This worker used the first acceptable test because she felt that with untrained adult subjects, duplicate tests in a large majority of well-controlled cases can be expected to agree within five per cent. Her

study showed that heat production based on per kilogram of body weight and per square meter of surface area decreased definitely from younger to older girls. Stark (16) later concluded that an example of abnormal body build illustrates the possibility of grave misconception that can arise from the use of a prediction standard that assumes a direct proportion between heat production and body weight.

Talbot (17), in describing his technique, says: "All clinical observations were checked first by the pulse rate and second by the character of the kymographic curve. When these indicated that a period might not be basal, it was eliminated. If a period passed the clinical test, the test of checking within five per cent was applied, and the values for satisfactory periods were averaged and used." This is contrary to a common custom of using the lowest test, believing it most nearly approaches the true basal state.

In 1935, Tilt (20) ran a second group of basal metabolism tests on Florida college women. The 48 subjects, 17 to 26 years of age, were normal young women following their usual dietary habits. Her findings showed the average basal metabolic rate for native Floridians to be

-14.1 per cent according to the modified Du Bois standard but for a group of the young women recently come from northern states, it was higher with a mean of -7.7 per cent. She reported no consistent relationship between basal metabolism and protein or Calorie intake and again, little, if any, change, due to seasonal variation.

McKittrick (13), in 1936, pointed out that Stillwater, Oklahoma, where Coons carried on her study, is 870 feet above sea level and that Tallahassee, Florida, where Tilt's work was done, is only 160 feet above sea level. Both studies reported lower basal metabolic rates than those usually accepted as standard. Laramie, Wyoming, where McKittrick attempted to determine the effect of altitude, is 7,148 feet above sea level. Her results with 100 Wyoming college women ranging in age from 17 to 26 years showed that the women at this University had higher rates as she expected. The average for the age-groups studied was -3.18 per cent according to the Du Bois standard as modified by Boothby and Sandiford (5). No subjects were used for these tests who had lived less than six months in Wyoming which was believed to be sufficient time to permit adjustment to the altitude. The results appeared to show that altitude may be considered a factor in

affecting the basal metabolic rate.

PROCEDURE

The respiration apparatus used for these tests was a 1935 Benedict-Roth model. This machine is of the closed circuit type and is provided with flutter valves to keep the air in circulation. Wilson's non-deliquescent soda lime was used to absorb carbon dioxide. The soda lime was changed frequently and, to further assure its efficiency, following each test some of the residual oxygen was discharged into a small beaker of barium hydroxide. If a precipitate of calcium carbonate appeared, the soda lime was changed.

Before beginning the investigation, an alcohol check was made on the machine to test its accuracy. Also, the thermometer and barometer were checked against suitable standards, and the timing apparatus for the kymograph with the record sheet.

It is necessary that the apparatus be air-tight. To test this, a 50-gram weight was placed on top of the spirometer bell before making a determination. If the machine were tight, a slight rise would be noticeable in the

tracing of the pen which would drop back in line again when the weight was removed. If there were a leak, a gradual and continuous drop of the pen would be evident. During each determination, the machine was tested again for leaks by placing the weight on the spirometer bell for a one-minute period. If a leak were present, the added weight would cause the oxygen to escape faster and the respiration tracings would assume a steeper angle. In such a case, the observation would be stopped, the source of the leak determined, and noseclip, mouthpiece, and tubing connections readjusted as necessary before resuming. The test for leakage was then repeated.

The subjects were freshman women at Kansas State College. They appeared to be normal physically as far as could be determined by observation and questioning. The students were notified in time to make the necessary preparations for the test. An effort was made to avoid times of emotional stress or excitement such as just before or following vacations, holidays, and examination weeks. No tests were given during any period of recognized strain or worry.

In this series of experiments, an attempt was made to avoid possible effects of menstruation on the basal

metabolic rate by asking the subjects to report for the test in the interval between the 10 days following the beginning of the last menstruation period and the eight days previous to the next expected one.

In order to secure as nearly as possible a true measure of the basal metabolism, certain standard procedures were followed. To insure complete muscular and mental relaxation, each subject was instructed to have eight to 10 hours rest in bed the night before the observation was made. She was further advised to come to the laboratory with the least possible expenditure of energy and preferably to ride. It was also desired to have the subject in a post-absorptive state, therefore, no food was taken from 12 to 18 hours previous to the observation. There were no restrictions on the drinking of water.

The subject reported to the laboratory as soon as possible after rising in the morning. She was required to lie quietly, comfortably covered, on a couch for 30 to 45 minutes after her arrival. This allowed time for her to recover from the muscular exertion of rising, dressing, and walking from her place of residence. While the subject rested, the machine was filled with oxygen, the record-

sheet placed on the kymograph drum, the pen filled with ink, and the machine tested for leaks.

After the rest period, the subject was fitted with a noseclip and the mouthpiece placed in position and adjusted comfortably. The two-way valve at the mouthpiece of the apparatus made it possible to breathe either the room air or the oxygen-rich air of the spirometer as desired.

After a two or three minute interval, or until the subject had become accustomed to the apparatus, the valve was closed and the recording begun. The temperature of the spirometer bell was read at the beginning and again at the end of each test and the average used for the calculations. If the rise amounted to one degree Centigrade or more, correction was necessary, amounting to 0.5 cc. of oxygen for each degree rise in temperature.

Two eight-minute tests were obtained for each subject and the best six consecutive minutes of each used for calculations. At the end of the first eight-minute period, the noseclip and mouthpiece were removed for a short rest interval of four or five minutes to prevent the subject's becoming fatigued. During this time, a fresh supply of oxygen was introduced into the spirometer and the kymograph drum was set back for the second test. Exactly the same

procedure was used each time. If two consecutive tests checked within five per cent, the determination was regarded as satisfactory. Frequently four, and in some instances six, tests were given one individual before a usable record was obtained. The low record was the one used as it was believed to be nearest to a true basal state.

The room temperature was kept approximately constant throughout the time of the test. The body temperature was taken orally, and if abnormal, the test was given anyway, but the record was not used and the subject was asked to return for another observation.

Pulse rate and respiration were determined by count just before the record was made. The latter was checked by counting complete tracings of the respirations on the kymographic record during a one-minute interval. Body weight and standing height were taken without shoes. Further information regarding the nationality, length of residence in Kansas, age, and date of the last menstrual period was secured after the test was completed. A light breakfast was served the subject before leaving the laboratory.

DISCUSSION OF RESULTS

The results concerning the heat production of 54 freshman women at Kansas State College are shown in table 1. Averages are given for each age-group and for the entire group. These are computed on the basis of age, height, weight, surface area, total Calories per 24 hours, Calories per kilogram per 24 hours, Calories per centimeter per 24 hours, and Calories per square meter per hour.

Basal Metabolism of Fifty-Four Kansas State College Freshman Women

Sub-ject:	Age:	Weight:	Height:	Surface: area :	Pulse: T ¹ :	Respiration: C ² :	Calories				Devia-tions ³	
							Per : 24 hrs.:	Per kg. per: 24 hrs. :	Per cm. per: 24 hrs. :	Per sq. m.: per hr. :		
no.:	yr.:	kg. :	cm. :	sq. m.:	per : min. :	per : min.:	per : min.:	:	:	:	:	:
26	17	41.5	152.5	1.325	83	13	14	1283	30.91	8.41	40.32	+ 7.8
78	18	57.7	161.9	1.595	61	11	12	1300	22.54	8.03	33.68	- 9.22
80	18	55.2	163.1	1.57	54	12	13	1295	23.45	7.94	34.05	- 8.71
110	18	60.9	167.6	1.67	58	7	10	1264	20.76	7.54	31.55	-15.43
4	18	74.0	166.4	1.80	58	8	16	1505	20.33	9.04	34.84	- 6.6
6	18	59.7	158.2	1.59	63	18	19	1344	22.52	8.50	35.23	- 0.02
14	18	59.4	151.8	1.55	73	20	24	1371	23.08	9.03	36.85	- 1.2
16	18	53.5	158.3	1.52	71	11	11	1197	22.38	7.56	32.39	-12.0
24	18	55.2	160.7	1.55	71	13	18	1277	24.33	7.94	34.32	- 8.01
30	18	63.5	168.2	1.71	77	14	16	1545	24.82	9.19	37.64	+ 0.93
76	18	50.0	154.7	1.46	66	9	16	1085	21.69	7.01	31.17	-16.45
86	18	55.5	161.4	1.57	67	13	16	1309	23.60	8.11	34.62	- 7.21
106	18	59.0	163.8	1.62	62	6	12	1183	20.05	7.22	30.42	-18.45
130	18	61.4	160.0	1.62	82	15	15	1246	20.30	7.79	32.04	- 2.33
8	19	59.1	157.4	1.59	65	22	23	1157	19.58	7.35	30.32	-18.43
28	19	62.7	163.7	1.66	77	14	18	1436	22.91	8.77	36.05	- 3.08
34	19	54.6	160.0	1.55	70	11		1143	20.96	7.16	30.73	-17.40
36	19	64.5	165.0	1.685	75	14	17	1470	22.79	8.91	36.35	- 2.33
44	19	69.3	167.3	1.76	61	16	16	1448	20.89	8.65	34.27	- 7.87
46	19	46.4	145.6	1.345	81	16	16	1189	25.62	8.16	36.83	- 1.00
58	19	55.3	150.2	1.49	66	14	15	1088	19.66	7.24	30.43	-18.20
60	19	75.1	167.2	1.84	65	10	15	1523	20.27	9.11	34.48	- 7.32
68	19	56.9	163.1	1.59	70	12	16	1303	22.89	7.99	34.14	- 8.22
70	19	62.6	168.5	1.69	53	11	17	1063	16.98	6.31	26.21	-29.23
84	19	54.6	159.6	1.545	52	11	14	1173	21.51	7.35	31.64	-14.93
102	19	46.5	159.6	1.44	56	10	13	1228	26.43	7.69	32.53	- 4.50
104	19	61.6	165.8	1.67	67	10	14	1411	22.92	8.51	35.42	- 4.79
112	19	56.5	154.0	1.52	79	14	20	1144	20.25	7.43	31.36	-15.71
114	19	58.4	167.0	1.64	54	13	12	1240	21.23	7.43	31.51	-15.29
116	19	53.8	160.5	1.545	69	13	13	1172	21.81	7.30	31.61	-15.02
122	19	66.1	162.4	1.695	61	11	14	1314	19.87	8.09	32.30	-13.16
124	19	58.3	157.7	1.58	69	15	17	1224	20.99	7.76	32.27	-13.27
134	19	55.2	157.0	1.54	59	10	13	1144	20.72	7.29	30.93	-16.86
136	19	58.2	164.5	1.62	64	11	15	1121	19.26	6.81	28.82	-22.52
2	20	64.7	161.6	1.67	80	11	17	1366	21.11	8.45	33.67	- 7.6
48	20	46.8	156.3	1.43	70	13	16	1240	26.48	7.91	36.13	- 2.10
72	20	51.6	162.9	1.53	60	12	14	1127	21.85	6.92	30.69	-16.83
74	20	59.1	164.0	1.63	77	11	17	1180	19.97	7.20	30.17	-18.25
92	20	59.7	150.9	1.54	67	8	11	1367	22.91	9.06	36.97	+ 0.19
100	20	48.4	150.0	1.41	70	13	16	1094	22.42	7.30	32.34	-12.36
38	21	63.5	165.1	1.685	75	11		1556	24.50	9.42	38.48	+ 4.74
62	21	53.8	158.1	1.52	62	11	16	1477	27.48	9.34	40.49	+ 9.73
118	21	65.1	162.0	1.68	59	12	16	1320	20.27	8.15	32.73	-11.29
120	21	58.3	163.3	1.61	61	15	15	1257	21.58	7.70	32.54	-11.82
128	21	47.3	151.5	1.40	61	11	14	1128	23.85	7.44	33.76	- 8.50
132	21	78.2	155.8	1.76	59	10	11	1390	17.77	8.92	32.72	-11.32
138	21	56.9	163.9	1.60	73	17	16	1361	23.91	8.30	35.44	- 3.96
18	22	52.4	159.2	1.52	79	14	18	1257	24.04	7.90	34.46	- 6.6
40	22	47.3	153.0	1.41	65	11		1224	25.88	8.00	36.16	- 2.02
108	22	60.1	157.8	1.59	59	8	13	1288	21.44	8.16	33.76	- 8.51
50	22	58.9	157.5	1.58	58	15	18	1238	21.02	7.86	32.92	-10.77
20	23	53.0	167.8	1.58	61	13	12	1407	26.55	8.39	37.11	+ 0.57
126	27	46.3	145.7	1.35	69	11	12	998	21.57	6.85	30.79	-15.87
12	28	69.9	171.0	1.81	75	9	14	1586	22.70	9.28	36.52	+ 0.2
Av.	19.7	55.4	159.3	1.73				1298	23.75	8.11	34.87	- 7.80

The basal metabolic rates were calculated according to the Du Bois standard as modified by Boothby and Sandiford (5) and compared, as a matter of interest, with the Harris-Benedict and Dreyer standards (table 2).

Fifty-one or 94.5 per cent of the subjects were Kansas-born or had lived in the state at least eight years before the study was made. The remaining three or 5.5 per cent had lived in Kansas less than six months, two coming from the state of Illinois and one from Missouri. The ages ranged from 17 to 28 years but the majority of the subjects were between 18 and 19 years old.

The results for 48 of the subjects were separated in order to have data on a strictly Kansas group. This also excluded age-groups represented by a single person. These women were from 18 to 22 years of age, and had lived in Kansas not less than eight years prior to the investigation.

Pulse rates varied from 61 to 83 per minute with a mean of 68.8 which is normal for women according to Kimber and Gray (9). Respirations by actual count averaged 15 per minute and by count of kymograph tracings, 12 per minute. In all cases, the number was lower when taken from the tracings. The discrepancy observed in the two methods

Table 2

Deviation in Basal Metabolism of College Women From Standards

Study	: Age	: Weight	: Height	: Total	Deviations			
					: Du Bois ¹	: Harris-Benedict	: Dreyer	
	: yr.	: kg.	: cm.	: per hr.	: per cent		: per cent	: per cent
Kansas								
Entire group	2	: 19.7	: 55.4	: 159.3	: 54.1	: - 7.8	: - 8.4	: - 7.0
18-22 yr. group		: 19.4	: 57.6	: 159.2	: 53.4	: - 9.0	: - 9.5	: -10.6
Oklahoma		: 20.1	: 55.5	: 162.9	: 51.9	: -13.2	: -10.1	: -11.7
Florida								
Natives		: 20.1	: 56.4	: 163.7	: 51.5	: -14.1	: -11.8	: -13.0
8 Northern women		: 18.0	: 53.7	: 161.7	: 54.0	: - 7.7	: - 7.8	: - 7.5
Wyoming		: 20.5	: 57.2	: 161.0	: 57.0	: - 3.2	: - 2.5	: - 3.2

¹As modified by Boothby and Sandiford

²Residents of Kansas eight years or longer, 48 subjects

of counting respiration has not been satisfactorily explained, but the fact that the count was uniformly lower during the test would indicate that the subject was not excited to the extent that breathing was accelerated. It may possibly suggest difficulty in breathing but this was not evidenced by any signs of discomfort.

The basal metabolism of the entire group averaged -7.8 per cent below the modified Du Bois standard, while the average for the strictly Kansas group fell to -9.0 per cent (table 3). On the same basis, 15 subjects, 28 per cent, had basal rates 15 per cent below normal; 10 subjects, 18 per cent, were 10 per cent below; 16 subjects, 30 per cent, within the range of 10 to 5 per cent below; and 11 subjects, 20 per cent, between 5 per cent below and 0.0. There were 7 subjects, 13 per cent, who were above 0.0.

The lowest individual basal rate obtained was -29.23 per cent and the highest was +9.73, making a range of 38.96 per cent for the 54 subjects. The range of the averages for the different age-groups was considerably narrower. The lowest average basal rate for any age-group in this study was -15.87 per cent but represented only a single individual 27 years old. The highest rate was

Table 3

Average Basal Metabolism of Nine Age-Groups of Kansas State College Freshman Women

Number of subjects :	Age : yrs. :	Weight : kg. :	Height : cm. :	Surface area : sq.m. :	Pulse : per min. :	Calories				Deviation ¹
						Per 24 hrs. :	Per kg. per 24 hrs. :	Per cm. per 24 hrs. :	Per sq. m. per hrs. :	
1	: 17	: 41.5	: 152.5	: 1.325	: 83	: 1283	: 30.91	: 8.41	: 40.32	: + 7.80
13	: 18	: 58.8	: 161.2	: 1.60	: 67	: 1302	: 22.30	: 8.07	: 33.75	: - 8.20
20	: 19	: 58.8	: 160.8	: 1.60	: 66	: 1250	: 21.38	: 7.77	: 32.55	: -12.47
6	: 20	: 55.1	: 157.6	: 1.54	: 71	: 1229	: 22.46	: 7.81	: 33.33	: - 9.56
7	: 21	: 60.4	: 160.0	: 1.61	: 64	: 1356	: 22.77	: 8.47	: 35.17	: - 8.77
4	: 22	: 54.7	: 156.9	: 1.53	: 60	: 1268	: 23.10	: 7.98	: 34.33	: - 6.93
1	: 23	: 53.0	: 167.8	: 1.58	: 61	: 1407	: 26.55	: 8.39	: 37.11	: + 0.57
1	: 27	: 46.3	: 145.7	: 1.35	: 69	: 998	: 21.57	: 6.85	: 30.79	: -15.87
1	: 28	: 69.9	: 171.0	: 1.81	: 75	: 1586	: 22.70	: 9.28	: 36.52	: + 0.2
Average	: 19.7	: 55.4	: 159.3	: 1.55	: 68	: 1298	: 23.75	: 8.11	: 34.87	: - 7.80

¹ From Du Bois as modified by Boothby and Sandiford

+7.80 per cent, and was obtained for the 17-year group. This also represented but one person. For the women who had been residents of Kansas eight years or longer, the age-groups were composed of a larger number of subjects and the difference was much less, ranging from -12.47 to -6.93 per cent.

According to Talbot (18): "If the metabolism of a normal girl between 8 and 18 years of age is compared with the average standard for girls of her weight, the chances are 81 per cent that it will fall within ± 15 per cent of the average. Although the rates of four-fifths of the normal girls fall within ± 15 per cent of the standard average, it is possible that the figure is even smaller for groups of older persons." Generally speaking, then, the averages for the entire group of Kansas women fell within normal limits.

Age made no consistent difference in Calories per hour, per square meter per hour, or per kilogram per 24 hours (table 3). This was to be expected, however, since the rate of growth affects the metabolic rate more than weight or age. This inconsistency for age held true for the entire series of tests as well as for the 18 to 22 year-group which contained the greatest number of subjects.

The Calories per square meter of body surface per hour for the entire group averaged 34.87 (table 4). This was 6.5 per cent above the Oklahoma, 7.7 per cent above the Florida, and 2.1 per cent below the Wyoming results.

The mean number of Calories per kilogram per 24 hours was 23.8 for the entire group (table 4). This was 5.5 per cent higher than for women in Oklahoma, 8.0 per cent higher than Floridians, and only 0.5 per cent lower than Wyoming women. For the 48 women, strictly Kansans, the average number of Calories per kilogram per 24 hours was 22.4 which is 5.9 per cent lower than that for the entire series. This group averaged 0.5 per cent and 2.7 per cent higher than the Oklahomans and Floridians respectively, and 6.7 per cent lower than the Wyoming women.

The average of the total Calories for the several age-groups varied from 998 to 1581, (table 3), making a difference of 58 per cent for the 54 women tested. The range per kilogram per 24 hours was from 21.38 to 30.91 Calories or a variance of 44 per cent; per centimeter per 24 hours, it was 6.85 to 9.28 or 35 per cent. The narrowest range was for Calories per square meter per 24 hours which amounted to only 30 per cent. These results further substantiate the conclusion made by Blunt et al. (4): "Comparisons made on the basis of Calories per square meter

Table 4

Comparison of Basal Metabolism of College Women in Different States

Study	: Age	: Weight	: Height	: Surface	Calories				: Devi- : ation ¹
					: Total per: : area : 24 hrs.	: Per sq. m.: : per hr. :	: Per kg. per: : 24 hrs.	: Devi- : ation ¹	
	: yr.	: kg.	: cm.	: sq. m.:					
Kansas									
Entire group	: 19.7:	: 55.4 :	: 159.3:	: 1.55 :	: 1298 :	: 34.87 :	: 23.8 :	: - 7.8	
18-22 year group ²	: 19.4:	: 57.6 :	: 159.2:	: 1.58 :	: 1282 :	: 35.87 :	: 22.4 :	: - 9.0	
Oklahoma	: 20.1:	: 55.5 :	: 162.9:	: 1.59 :	: 1245 :	: 32.6 :	: 22.5 :	: -13.2	
Florida	:								
Natives	: 20.1:	: 56.4 :	: 163.7:	: 1.60 :	: 1237 :	: 32.2 :	: 21.9 :	: -14.1	
8 Northern women	: 18.0:	: 53.7 :	: 161.7:	: 1.55 :	: 1295 :	: :	: 24.1 :	: - 7.7	
Wyoming	: 20.5:	: 57.2 :	: 161.0:	: 1.60 :	: 1386 :	: 35.61 :	: 23.9 :	: - 3.2	

¹From Du Bois as modified by Boothby and Sandiford

²Residents of Kansas eight years or longer, 48 subjects

seem to show the least variation from average for different individuals, whether of normal or unusual build." Du Bois goes further in his statement: "The Calories calculated according to surface area are practically the same for thin or fat persons as for those of average build, but there are large discrepancies in formulae based on weight or height alone."

SUMMARY

The basal metabolism for 54 freshman women enrolled in Kansas State College, selected at random, averaged -7.8 per cent below the Du Bois standard as modified by Boothby and Sandiford.

The basal rate for 48 of these women, who had lived in the state at least eight years prior to this study, was -9.0 per cent.

More studies are necessary before definite standards can be formulated.

ACKNOWLEDGMENT

The writer wishes to express her appreciation to Dr. Martha S. Pittman, Head of the Department of Food Economics and Nutrition, and to Miss Bernice Kunerth, Instructor in the same department, for assistance and guidance in the preparation of this thesis and to extend her thanks to the students who so kindly served as subjects for the study.

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