BASAL METABOLISM OF TWENTY-FIVE KANSAS COLLEGE WOMEN BETWEEN TWENTY-FIVE AND THIRTY YEARS OF AGE

by

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INTRODUCTION

Studies of the basal metabolism of college women are now in progress in several states as part of a regional cooperative project. It was desired to extend the investigations being made in Kansas to include a slightly older group of women living under college conditions and to compare the results with those of younger women living in Kansas and in other states.

REVIEW OF LITERATURE

Early in the twentieth century, American physiologists and nutrition workers began to study in this country the basal metabolism and energy production of the human body. Atwater and Benedict (1903) were among the first workers in the United States to report detailed experiments measuring metabolic rates. With their respiratory calorimeter they made many tests and accumulated valuable data regarding the conservation and transformation of matter and energy in the body, the demands of the body for nutriment, the effects of muscular work upon such demands, and the actual nutritive value of different food materials and their constituents.

Lusk, according to Du Bois (1936), devoted his attention chiefly to the effects of different kinds of foods on the intermediary metabolism. Much of Lusk's work was done with diabetics, using a small apparatus. This author also states that about this time Benedict and his associates in Boston developed a comparatively simple respiration apparatus suitable for use in hospitals. The need for this device followed Magnus-Levy's demonstration of the increase of metabolism in cases of exophthalmic goiter. Still simpler forms of apparatus have been invented since these early days, until now thousands of such machines are used by physicians and research workers throughout the world.

In recent years, a number of workers have been especially interested in the study of the basal metabolism of young college women between 16 and 25 years of age. Benedict and Gustafson (1928), working at Wellesley College, reported a seasonal variation in basal metabolism. They found it tended to be at a comparatively low level in winter and to rise to a somewhat higher level in the spring and summer.

McKay (1930) made 236 observations of the basal metabolism of 91 young Ohio women between 14 and 18 years of age and 164 observations of five young women 21 to 24 years of age. She determined the average total basal heat production for 24 hours, and per kilogram per 24 hours. She found the heat production figures higher than those of Benedict's Girl Scouts, but lower than the existing Du Bois standard. She determined day by day variations in heat production and found that, although seasonal variation was small, the basal metabolism tended to rise in April, May, and June. These results were in accord with the report of Benedict and Gustafson (1928).

Tilt (1930) working in Florida with 52 women students between 17 and 25 years of age, found the average metabolic rate for this group was 9.9 per cent below the Harris-Benedict standard, and 10.6 per cent below that of Aub and Du Bois. Her data indicated no change in basal metabolism with change of season. Eight subjects indulging in greater physical activity than the others had an average basal metabolism agreeing closely with the average of the entire group. As 54 per cent of her subjects fell below the Aub-Du Bois standard, Tilt suggested that women living in a southern climate may maintain a lower basal rate than those living in the northern states.

Remington and Culp (1931) determined the basal metabolism of 93 nurses and 43 medical students living in South Carolina. They found the average basal rate was about 10 per cent lower than the Aub-Du Bois standard. Climate, relative amounts of iodine in the human environment, dietary habits, and the state of nutrition were not considered responsible for the low values.

Mason and Benedict (1931) studying women of south India found a low basal metabolic rate for this group. They suggested that possible causes for this low rate other than race might be the state of relaxation of these people while awake, and the tropical climate.

Coons (1931) compared the basal metabolic rates of 38 overweight, and of 80 underweight Oklahoma college women between 17 and 28 years of age with standards set up for normal subjects, in order to determine the relationship of nutritional status to basal metabolism. She found that overweight individuals tended to metabolize at a higher rate, and underweight ones at a lower rate when expressed as total calories, calories per centimeter, or calories per square meter. The effect of under- and over-nutrition seemed to manifest itself even when weight variations were slight. The magnitude of the deviation tended to increase with weight variation, but not in the same proportion.

Coons and Schiefelbusch (1932) in a later study of Oklahoma college women, attempted to ascertain the effects of diet on basal metabolism. These workers suggested that prolonged undernutrition is one factor in many cases of low metabolism.

At the University of Wisconsin, Stark (1933) studied the basal metabolic rate of girls 17 to 20 years of age for the purpose of setting up a valid standard of normality for such subjects. She compared her results with existing standards finding that the Aub-Du Bois was from 8 to 15 per cent too high; the Harris-Benedict, 6 to 10 per cent too high, and the Benedict, 1 to 8.5 per cent too low. Mid-western girls made up 85 per cent of her subjects. She found conclusively a downward trend of heat production from the younger to the older girls, and a low metabolic rate during or shortly following the menstrual period.

A later study by Mason and Benedict (1934) was made to determine if relaxation while awake might account for the low metabolic rate they had observed in Indian women. However, their observations showed the fall that came with sleep was approximately the same as for western women so they concluded that the state of relaxation of the body while awake could not account for the difference they had noted.

Mason (1934) measured the basal metabolism of 34 European women living in India finding it low according to all the commonly used stnadards. It was, however, considerably higher than the basal metabolic rate of the native Indian women previously studied. Mason therefore concluded that something more than climate was necessary to explain the difference in metabolic rate obtained for the two groups. Her data suggest that only about 5 per cent of the low metabolism of the Indian women can be accounted for by the effect of the tropical climate.

Later work by Tilt and Walters (1935) with 30 normal Florida women 17 to 26 years of age indicated the average deviation from the Harris-Benedict standard was -13.0 per cent, while it was -14.1 per cent from the Aub-Du Bois standard as modified by Boothby and Sandiford (1929). Hence, she again concluded as in her earlier work (1930), that the basal metabolic rate was lower for women living in Florida than for those living in northern states. She found no consistent relationship between the basal metabolism and the protein and caloric intakes.

Benedict (1935) carried on 18 consecutive days of self-experimentation to determine the basal metabolic rate of a well-conditioned man in complete muscular and mental repose 12 hours after eating. He found body temperature, pulse, respiration rates, respiratory quotient, oxygen consumption, and insensible perspiration extraordinarily uniform from day to day, and that they were not affected by variations in "length and depth of sleep," the normal fluctuations of room temperature, or rather considerable variations in character and amount of the food eaten the evening before the test was made. A meal fairly high in carbohydrate eaten at noon resulted in a high respiratory quotient the next morning. The insensible perspiration was closely correlated with the basal heat production. Emotional disturbance caused a marked increase in metabolism which did not subside for several days.

A definite lowering of basal heat production was reported for subjects on submaintenance diets by Johnston and Maroney (1936). While basal metabolism could in most instances be brought from subnormal to normal levels by these workers, only slight increases beyond normal were obtained. Such increases, calculated on the basis of surface area of the body, were possible with a high protein intake. Maximal elevation of the basal metabolic rate was the result of a high intake of calories as well as protein.

McKay and Patton (1936), continuing their study of Ohio women, determined the basal metabolism of 73 older women ranging from 35 to 71 years of age. They found that the age factor was insignificant for women in the two younger age groups (35 to 39, and 40 to 49 years), however, the two older groups (50 to 59, and 60 to 69 years) showed a decrease in heat production on the basis of total calories, calories per centimeter, and calories per kilogram per 24 hours, as well as on the basis of calories per square meter per hour. Hence, she concluded that basal metabolism of women remains at a fairly uniform level until the age of 50 or thereabouts is reached, after which the heat production declines to a lower level.

Contrary to the theory that basal metabolism is proportional to body surface, Talbot (1936) reported that a comparison of heat production to body weight was quite as accurate for general usage as a comparison with body surface, and more accurate for young children and pathological cases.

McKittrick (1936) of the University of Wyoming found the deviation from the Aub-Du Bois standard only -3.18 per cent, and from the Harris-Benedict standard, -2.54 per cent for 100 normal college women living in Wyoming. She concluded that high altitude raised the basal metabolism and thus explained her high results.

The need for specifying the standard used when reporting metabolic tests was emphasized by Jenkins (1931). He discussed in detail the merits of present standards, suggesting that too many exist. He urged that an attempt be made to make the present ones more accurate rather than to develop new ones.

Wang (1936) used 9 standards to compare the basal metabolism of 34 adolescent girls 11 to 20 years of age. She found the Dreyer, Benedict, and Talbot standards most satisfactory. Those of Aub-Du Bois proved too high. In the case of total calories, the highest coefficient of correlation was with surface area, followed by height, and then by weight. When calories per kilogram were used, all coefficients were negative, weight giving the highest value, but closely followed by surface area.

Contrary to Jenkin's advice, Read and Barnett (1936) discussed new formulas for predicting the basal metabolic rate from pulse rate and pulse pressure. He regarded the formulas as valuable when facilities for measuring oxygen consumption are not available, and to check the metabolic rate as determined by indirect calorimetry.

The growth curves and basal metabolism of 39 post-pubescent girls were studied by Lewis (1936) to determine the relation of basal metabolism to the chronological and physiological age and the rate of growth of these girls. His data confirmed the previously established trend for basal metabolism at this age range based on chronological age, but gave no indication of any relation to physiological age or the rate of growth.

Shinkle (1937) found the average basal metabolism of 54 freshmen women enrolled in Kansas State College to be

7.8 per cent below the Du Bois standard. The basal rate of those women who had lived in Kansas at least eight years prior to the study was -9.0 per cent.

Lewis (1938) experimented with 100 male subjects of varying ages, 20 of whom were in each decade from 40 to 89 years. He found a gradual fall in basal metabolism from the age of 40 to 89, but this decline appeared to be arrested between 50 and 79 years, and considerable variation existed in each age group.

Talbot's latest study (1938) suggested that during acute undernutrition there was a rapid loss of weight and a corresponding loss of heat production, and that the greater the degree of malnutrition, the greater the heat production loss. He believed that in order to obtain knowledge of the state of malnutrition, the absolute heat production should be compared with standards expressed in terms of average weight for height.

PROCEDURE

A 1935 Benedict-Roth model of respiration apparatus was used for taking the basal metabolism tests. This is a closed circuit machine of a portable type in which the air is kept in circulation by flutter valves. Wilson's non-deliquescent soda lime was used to absorb the carbon dioxide. The efficiency of the soda lime was tested frequently by forcing some of the residual oxygen into a test tube containing barium hydroxide. If carbon dioxide were present it would be indicated by a precipitate of barium carbonate which necessitated changing the soda lime. The automatic timer was checked before the patient was attached to the machine.

The subject was attached to the respiration apparatus by means of a soft rubber mouth piece and a clamp applied to the nose to insure breathing through the mouth. The subject inhaled from the spirometer chamber which was filled with oxygen, and exhaled through soda lime, which removed the carbon dioxide and permitted the oxygen to be used again. The spirometer was carefully counterbalanced so that it rose and fell with each respiration with only slight resistance. Its movements were recorded on a kymograph by means of a special pen. The spirometer temperature was recorded before and after each test and the average used for the calculations. If a rise of one degree or more Centigrade occurred, correction was made by the addition to the measured oxygen consumption of 0.5 cc. of oxygen for each degree rise in temperature.

To test for leakage, a 50-gram weight was placed on top of the spirometer bell during a test. If the system were airtight, a distinct elevation would appear in the tracing on the drum. On removal of the weight, the pen would drop back to its normal position and the tracing resume its original slope. In case of leakage, the rise would not occur; then the test would be discarded.

The spirometer bell was calibrated so that it contained exactly 20.73 cc. of oxygen per mm. of its height. One millimeter fall of the bell in six minutes, therefore, was equivalent to 20.73 cc. oxygen or 207.3 cc. oxygen for an hour as the latter is made up of ten 6-minute periods. One liter of oxygen has a heat equivalent of 4.825 Calories under the conditions of this test; 207.3 cc. oxygen is equal to 0.2073 liters and when multiplied by 4.825 is equal to one Calorie per hour. On this basis the millimeters of oxygen used by a subject in six minutes may be assumed, after corrections for temperature and pressure are made, to be a measure of the Calories burned per hour.

Twenty-five college women, 25 to 30 years of age inclusive, were chosen at random from the faculty and student group of Kansas State College. These women to all outward appearances were normal and in good physical condition. Explanation of the principles involved, and standard directions were given each subject the day before the first test was made.

Because the metabolism might be affected by menstruation, the tests were given only in the interval between the tenth day after the beginning of the last menstrual period and eight days previous to the next. No tests were made at times of particular strain or stress. Examination days were avoided. Every effort was made to have the subject as nearly normal as possible. Eight hours rest in bed were required on the night before the test was made. The subject ate nothing after supper the night before, and refrained from smoking for the same length of time. There was no restriction on water intake. In the morning, the subject arose, dressed leisurely, and rode to the laboratory in order to avoid undue activity. She then rested in bed for 30 minutes or longer before taking the test in order to recover from the muscular exertion of rising, dressing, and coming to the laboratory.

While the subject was resting, the timer was checked, the pen filled with ink, the spirometer bell with oxygen, and everything made ready for the test. The temperature of the subject was taken by mouth, and the pulse rate recorded for two half-minute periods. Respiration was counted for one minute without the knowledge of the subject, lest she become self-conscious and therefore abnormal in her breathing.

The nose clamp was then placed in position, and the investigator made certain that no air could be forced through the nostrils. The subject inserted the sterilized rubber mouthpiece after which she was allowed to breathe for a few minutes through the machine before the graphic record was started. This allowed time for adjustment to the apparatus. The tests were continued over a period of eight minutes, but calculation was made only upon the best six consecutive minutes.

After the first test, the nose clamp and mouthpiece were removed and the subject was allowed a brief rest while the spirometer bell was again filled with oxygen and the temperature recorded.

When the second test was completed, the height in centimeters, and weight in kilograms were taken with shoes removed. Other information, such as age and date of menstrual period was recorded, after which a light breakfast was served.

DISCUSSION OF RESULTS

The results concerning the heat production of 25 Kansas college women between 25 and 30 years of age are shown in Table 1. These are computed on the basis of age, 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.

Table 1. Mean Metabolic Rates of Twenty-five Kansas College Women.

Age	Subject	Height	Weight	Surface area	Temperature	Calories: Per 24 hours: Total		Calories: Per 24 hours: Per kg.		Calories: Per 24 hours: Per cm.		Calories: Per hour: Per sq. m.		Percentage deviation from Aub-Du Bois as modified by Boothby	
Yrs.	No.	cm.	kg.	sq. m.	Deg. F.	all[1]	checks[2]	all[1]	checks[2]	all[1]	checks[2]	all[1]	checks[2]	all[1]	checks[2]
25	1	153.00	50.35	1.45	97.7	1389.54		27.60		9.08		39.77		8.67	
25	2	181.61	66.55	1.85	97.8	1576.86	1560.24	23.70	23.50	8.69	8.59	35.61	35.27	- 2.70	- 3.63
25	3	178.00	69.39	1.85	97.2	1175.28	1079.88	16.94	15.56	6.60	6.07	26.47	24.32	-27.68	-33.55
25	4	169.70	85.82	1.95	97.6	1425.79	1400.34	18.29	16.30	8.40	8.26	30.45	29.92	-16.78	-18.21
25	5	157.00	53.85	1.52	97.4	1106.82	1106.82	20.54	20.54	7.05	7.05	30.32	30.32	-17.16	-17.16
25	6	159.00	50.63	1.50	97.3	1202.82	1136.52	23.74	22.46	7.32	7.15	33.41	31.57	- 8.71	-13.75
26	7	173.80	57.65	1.68	97.6	1371.42		23.79		7.89		34.01		- 7.07	
26	8	164.00	53.26	1.56	98.4	1252.44	1227.28	23.51	23.06	7.64	7.49	33.46	32.78	- 8.59	-10.43
26	9	169.93	61.56	1.70	97.7	1396.54	1360.32	22.66	22.11	8.21	8.01	34.18	33.34	- 6.61	- 8.89
26	10	171.60	58.09	1.67	97.9	1267.68		21.83		7.39		31.63		-13.58	
26	11	165.60	55.56	1.60	97.9	1226.34	1213.04	22.07	21.83	7.41	7.33	31.94	31.59	-12.74	-13.69
26	12	158.90	50.70	1.50	97.7	1153.00	1153.00	22.70	22.70	7.30	7.30	32.10	32.10	-12.30	-12.30
27	13	157.60	50.95	1.49	98.3	1314.11	1290.48	25.79	25.33	8.34	8.19	36.75	36.09	0.42	- 1.38
27	14	164.80	56.55	1.60	98.2	1559.10	1559.10	27.57	27.57	9.46	9.46	40.60	40.60	10.93	10.93
27	15	163.80	44.44	1.44	97.7	1265.10		28.45		7.72		36.74		0.38	
27	16	159.00	49.68	1.48	97.7	1133.34	1114.16	22.82	22.43	7.13	7.01	31.91	31.37	-12.82	-14.30
27	17	169.80	57.46	1.65	97.1	1358.70	1323.92	24.28	23.66	8.01	7.80	33.59	32.31	- 6.16	- 8.94
27	18	150.70	46.30	1.39	98.3	1007.00	1007.00	21.80	21.80	6.70	6.70	30.30	30.30	-17.20	-17.20
27	19	168.70	51.82	1.58	97.8	1207.48		23.31		7.16		32.04		-12.46	
28	20	169.00	54.15	1.60	98.0	1157.64	1137.92	21.42	20.80	6.85	6.73	30.16	29.51	-17.68	-19.47
28	21	154.00	43.29	1.36	98.5	1079.16	1079.16	24.94	24.94	7.01	7.01	33.06	33.06	- 9.67	- 9.67
29	22	165.30	64.50	1.70	97.4	1278.42	1305.36	19.92	20.31	7.73	7.90	31.33	31.99	-13.66	-12.09
29	23	163.40	61.02	1.64	97.6	1288.80	1307.04	21.12	21.42	7.89	8.00	32.74	33.20	-10.51	- 9.25
30	24	161.90	52.65	1.53	97.9	1189.56	1189.56	22.60	22.60	7.35	7.35	32.40	32.40	-11.49	-11.49
30	25	169.00	54.57	1.61	97.3	1141.38	1129.76	29.54	29.24	6.75	6.68	29.54	29.87	-19.30	-20.12

1. Mean of all tests.
2. Mean of tests that check within five per cent.

The mean basal metabolic rate of this group of women of 25 to 30 years expressed as percentage deviation from the Aub-Du Bois standard as modified by Boothby, was -11.88. This is lower than the findings of Shinkle (1937), who reported that the basal metabolic rate for 54 freshmen Kansas women, most of whom ranged from 17 to 23 years of age, showed a -7.8 per cent deviation from the Aub-Du Bois standard.

Results of three years of experimentation on basal metabolism at Kansas State College as part of a regional project concerning the nutritional status of college women show a mean percentage deviation of -8.96 for 110 college women between 17 and 23 years of age. All of these findings support the usually accepted theory that as the age of an individual increases his metabolic rate undergoes a gradual decrease.

It is probable that as the number of subjects in the 25 to 30 year group are increased, that the decrease in basal metabolism with age will still be apparent, but less marked than with the small group of 25 subjects used in this study.

Sherman (1937) has pointed out that a new-born infant has a lower basal metabolic rate than an older child. He suggested that there is an abrupt rise in rate after birth until about the second year of life. This rise is attributed to the development of the muscular system and the gradual increase of muscle tonus. After two years there is a general downward trend of the rate until death. The effect of puberty causes the curve to be uneven in its decline. According to Sherman, MacLeod has shown a definite increase in metabolic rate in girls of 12 to 13 years during the period of prepubescence, whereas Benedict and Henry found no such increase. Whether or not this rise occurs, remains a matter of controversy.

Metabolic rate is generally assumed to decrease throughout adult life, although there is apparently a smaller drop between 20 and 30 years of age than in any other decade. Benedict believed, according to Sherman (1937), that during this period the effect of the increase in age was offset by increase in body weight and improvement in physical condition.

Boothby and Sandiford (1929) found a rapid decrease in basal metabolism with age in male children of 5 to 21 years and an even more rapid decrease with age in female children of 5 to 17 years. This was followed in both sexes by a gradual and nearly parallel decline to old age.

Blunt et. al. (1926), experimenting on 46 girls from 8 to 18 years of age, reported a decrease from 43.4

Calories per square meter per hour for the younger girls to 41.0 for the older ones. While these findings indicated a decrease with age, the heat production was considerably higher for the 18-year old subjects of Blunt's study than that of thirty-three 18-year old Kansas women[1] whose mean metabolism was 34.2 Calories per square meter per hour.

From a study of the metabolism of older women, Boothby and Sandiford (1929) reported for 20 to 24 years a rate of 36.9 Calories per square meter per hour; for 25 to 29 years, 36.6, and for 30 to 34 years a rate of 36.2. These results indicated but slight decline in basal heat production between 20 and 35 years.

McKay (1930) reported the mean basal metabolism for 91 Ohio girls of 14 to 18 years as 36.40 Calories per square meter per hour, and for 53 subjects of 17 to 23 years as 33.33 Calories per square meter per hour. This latter value is close to that of the 25 to 30-year old subjects of this Kansas study whose mean metabolic rate was 32.21 Calories per square meter per hour. This again supports the theory that the basal metabolic rate decreases with age, however, the drop observed for the

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1. Unpublished material, Department of Food Economics and Nutrition, Kansas State College of Agriculture and Applied Science.

Kansas group may be expected to change to some extent with a larger number of subjects.

McKay showed in later work (1936) that the average heat production expressed in Calories per square meter per hour was practically the same for groups of women of 35 to 39, and 40 to 49 years of age, respectively. This indicated that age was an insignificant factor in its effect on heat production for these groups of older Ohio women.

Although the results of these experiments on Kansas college women are in accord with the citations above, much more experimental data are needed to establish more definitely the decrease in metabolic rate with age.

Table 2 shows no consistent decrease for any factor measured from one year to the next from 25 to 30 years inclusive. While the numbers within this group are too few to permit drawing any conclusions, the results would seem to agree, to the extent of the last half of the period, with the statement of Sherman (1937) that little decline occurs from 20 to 30 years of age.

Wide individual variation was observed for each particular measurement. For example, Calories per square meter per hour ranged from a low of 24.32 to a high of 40.60 for individuals within this group, and total Calories,

Table 2. Mean and Range of Metabolic Rates of Twenty-five Kansas College Women Divided Into Six Age Groups.

Age group	Sub-jects	Mean and range	Height	Weight	Surface area	Tempera-ture	Calories								Percentage deviation from Aub-Du Bois standard as modified by Boothby	
							Per 24 hours				Per hour					
							Total		Per kg.		Per cm.		Per sq.m.			
Yrs.	No.		cm.	kg.	sq. m.	Deg. F.	all	checks	all	checks	all	checks	all	checks	all	checks
25	6	Mean	166.39	62.77	1.69	97.50	1312.85	1256.76	21.80	19.67	7.86	7.42	32.67	30.28	+ 0.73	-17.26
		Range	153.00	50.35	1.45	97.20	1106.82	1079.88	16.94	15.56	6.60	6.07	26.47	24.32	-27.68	-33.55
			181.61	85.82	1.95	97.80	1576.86	1560.24	27.60	23.50	9.08	8.59	39.77	35.27	+ 8.67	- 3.63
26	6	Mean	167.31	56.17	1.62	97.87	1277.90	1238.41	22.76	22.43	7.64	7.53	32.89	32.45	-10.15	-11.33
		Range	158.90	50.70	1.50	97.60	1153.00	1153.00	21.83	21.83	7.30	7.30	31.63	31.59	- 6.61	- 8.89
			173.80	61.56	1.70	98.40	1371.42	1360.32	23.79	23.06	8.21	8.01	34.46	33.34	-13.58	-12.30
27	7	Mean	162.06	51.03	1.52	97.87	1263.55	1258.93	24.86	24.16	7.79	7.83	34.56	34.13	- 5.27	- 6.18
		Range	150.70	44.44	1.39	97.10	1007.00	1007.00	21.80	21.80	6.70	6.70	30.30	30.30	-17.20	-17.20
			169.80	57.46	1.60	98.30	1559.10	1559.10	28.45	27.57	9.46	9.46	40.60	40.60	+10.93	+10.93
28	2	Mean	161.50	48.72	1.48	98.30	1118.40	1108.54	23.18	22.87	6.93	6.87	31.61	31.29	-13.68	-14.57
		Range	154.00	43.29	1.36	98.00	1079.16	1079.16	21.42	20.80	6.85	6.73	30.16	29.51	-17.68	-19.47
			169.00	54.14	1.60	98.50	1155.64	1137.92	24.94	24.94	7.01	7.01	33.06	33.06	- 9.67	- 9.67
29	2	Mean	164.35	62.76	1.67	97.50	1283.61	1306.20	20.52	20.87	7.81	7.95	32.04	32.60	-12.09	-10.67
		Range	163.40	61.02	1.64	97.40	1278.42	1305.36	19.92	20.31	7.73	7.90	31.33	31.99	-13.66	-12.09
			165.30	64.50	1.70	97.60	1288.80	1307.04	21.12	21.42	7.89	8.00	32.74	33.20	-10.51	- 9.25
30	2	Mean	165.45	53.61	1.57	97.60	1165.47	1159.66	26.07	25.92	7.05	7.02	30.97	31.14	-15.40	+15.81
		Range	161.90	52.65	1.53	97.30	1141.38	1129.76	22.60	22.60	6.75	6.68	29.54	29.87	-19.30	-20.12
			169.60	54.57	1.61	97.90	1189.56	1189.56	29.54	29.24	7.35	7.35	32.40	32.40	-11.49	-11.49
		Mean of Means						1237.29		22.44		7.53		32.21	-11.88	

from 1007 to 1560. No uniform rise or fall could be noted and great personal variation was observed.

There has been much discussion of the effect of build upon metabolic rate. Table 3 shows a comparison of the findings for five subjects of small body surface with an equal number with large body surface. It was found that the mean basal metabolic rate was 34.24 Calories per square meter per hour for the smaller subjects and 30.97 for the larger ones. The reverse was true when the comparison was made on the basis of body weight, as the smaller women metabolized 25.12, and the larger ones only 19.56 Calories per kilogram per 24 hours. This is not in entire agreement with the theory that basal metabolism is proportional to the amount of body surface, and is somewhat in accord with Talbot's statement (1936) that heat production is not dependent on surface area, but on the amount of active protoplasmic tissue in the body.

The effect of weight on basal metabolism is shown in Table 4. It was observed that with an increase in weight there was an increase in total Calories, and in Calories per centimeter per hour, but a decrease in Calories per kilogram per 24 hours and in Calories per square meter per hour. This checks with Blunt's statement (1926), that overweight girls tend to have a lower metabolic rate

Table 3. The Effect of Body Surface and Weight on Basal Metabolism.

Subject	Body surface	Calories per sq. m. per hr.	Calories per kg. per 24 hr.
	Sq. m.		
21	1.36	33.06	24.94
18	1.39	30.30	21.80
15	1.44	36.74	28.45
1	1.45	39.70	27.60
16	1.48	31.48	22.82
Mean	1.42	34.34	25.12
9	1.70	33.34	22.11
22	1.70	31.99	20.31
2	1.85	35.27	23.50
3	1.85	24.32	15.56
4	1.95	29.92	16.30
Mean	1.81	30.97	19.56

Table 4. Mean Heat Production Related to Weight.

Weight	Subjects	Mean total Calories	Mean Calories		
			Per kg. per 24 hr.	Per cm. per 24 hr.	Per sq.m. per hr.
kg.	No.				
43 - 50	4	1116	24.41	7.11	32.87
50 - 54	10	1197	23.76	7.42	32.65
55 - 58	5	1347	23.74	7.97	34.03
61 - 69	5	1323	20.59	7.71	31.62
85	1	1400	16.30	8.26	29.92

expressed as Calories per kilogram than do underweight girls. Coons (1931) found this to be true with Oklahoma women. According to generally accepted standards, the basal metabolism increases with size but not in proportion to weight. Consequently the metabolism per unit of body weight may be expected to decrease as the weight increases. Such was the case with these subjects.

Little difference was found in basal metabolism expressed as Calories per square meter per hour for women subjects 17 to 26 years of age living in Minnesota, Wisconsin, Iowa, Ohio, Kansas, Oklahoma, South Carolina, and Florida (Table 5). The mean rate for Florida, which is most southern in location, was 33.40 Calories per square meter per hour, while that for Minnesota in the north was 34.23 Calories per square meter per hour for subjects ranging from 17 to 23 years of age. This indicates but slight variation for these two extremes, and is contrary to the general belief that the basal metabolism decreases with latitude. Results from a greater number of states should be reported before the effect of this factor upon the metabolic rate can be determined definitely.

Table 5. Mean Calories Per Square Meter Per Hour for Women of Different Age Groups in Several States.

State	Age group	Subjects	Calories per sq. m. per hour
	Yrs.	No.	
Minnesota	17 - 23[1]	86	34.23
Wisconsin	17 - 20	97	34.01
Iowa	17 - 23[1]	138	34.84
Ohio	14 - 18	91	36.40
	17 - 23[1]	53	33.33
	30 - 39	18	33.99
	40 - 49	24	33.64
	50 - 59	18	31.57
	60 - 69	9	30.29
Kansas	17 - 24[1]	112	33.81
	25 - 30[1]	25	32.21
Oklahoma	17 - 23	25	34.70
South Carolina	19 - 24	24	34.40
Florida	17 - 26	29	33.40

1. Unpublished material, Department of Food Economics and Nutrition, Kansas State College of Agriculture and Applied Science.

FINDINGS

1. The mean basal metabolic rate for 25 Kansas college women between twenty-five and thirty years of age expressed as percentage deviation from the Aub - Du Bois standard as modified by Boothby was -11.88 per cent.

2. The mean Calories per square meter per hour for this older group of 25 Kansas women was 32.21 as compared with 33.81 Calories per square meters per hour for 112 Kansas women ranging from seventeen to twenty-four years of age. It may be assumed that a reduction in metabolic rate with increasing years was indicated, but more experimental data are needed for conclusive evidence.

3. Little difference was found in the Calories per square meter per hour for women subjects from seventeen to twenty-six years of age from Minnesota, Wisconsin, Iowa, Ohio, Kansas, Oklahoma, South Carolina, and Florida. This is contrary to the general belief that the basal metabolism decreases with the latitude.

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