BASAL METABOLISM OF WOMEN IN LATER MATURITY

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TABLE OF CONTENTS

TABLES

Tables (Continued)

GRAPHS

INTRODUCTION

The study of the process of aging, or geriatrics, has been neglected until very recently. Perhaps because senescence has been considered the inevitable decline of life. In fact, in conversation aging is a subject usually avoided as something disgraceful. To admit advanced years seems to carry with it a loss of social respect. Dr. Edward Stieglitz, consultant in Gerontology, National Institute of Health, Washington, D. C., points out the erroneousness of this attitude: "to compensate for the decrements in certain physiologic and mental capacities there occur increments in other capacities." That is, a man's adaptations for skill may decrease but his judgement increase. Dr. Stieglitz feels that to take advantage of man's ability to use his acquired capacities during the "older decades" we should try to aid in maintaining his physiological condition to a higher degree.

The study of the aging process is a practical necessity today because of the increasing number of people over 60 years of age. From a statistical study compiled by the United State's Census Bureau (1938) it has been

pointed out that 6 to 7% of the population of the United States is over the age of sixty and it has been predicted that by 1980, 15% of the population will consist of persons about this age. There is developing a dramatic change in the population structure that has not been precedented, and the need to learn about aging seems urgent. It seems timely to make a conscientious study of the processes of aging in order to enlarge these people's capacity for living. If our population is to consist of people in "later maturity" in increasing numbers, it certainly seems to our advantage to make their longevity a more healthful and productive state.

Statistics from the National Health Survey, (1935 and 1936) show that over 1% of more than three million persons of the older age group were chronic invalids. The diseases in order of importance in causing prolonged and/or progressive disabilities were: 1, mental and nervous diseases; 2, cardiovascular-renal diseases; 3, the arthropathies; and 4, tuberculosis.

Overweight may contribute to chronic cardiovascular renal diseases and underweight may lower body resistance to infections such as tuberculosis which sometimes results in chronic illness.

Since the body is maintained by the energy derived from ingested food, the food needs during the later decades would appear to be important in the maintenance of good health.

An important part of the total energy used by the body is basal energy which is the amount of energy required by the body to maintain minimum cell metabolism, that is, basal metabolism.

Benedict and Meyer (1932) conclude that "none of the existing standards may be considered to predict accurately the metabolism of any individual elderly woman". Some data, but not sufficient for reliable conclusions, has been accumulated since this time.

A study of basal energy needs of the body in the later decades seemed pertinent. In this study the basal metabolic rates of twenty women between the ages of 48 and 77 years were observed. The study was a part of a larger metabolic study on older women being investigated by the Foods and Nutrition Department of Michigan State College.

REVIEW OF LITERATURE

The term "basal metabolism" was introduced into the literature as representing a translation of the German word "Grundumsatz", which is a combination of the German word "grund", meaning bottom or foundation, and the word "umsatz", meaning returns or sales. Basal metabolism is usually defined as the heat production of an individual who is completely relaxed, but not asleep, twelve hours after the ingestion of food, and in an environment free of outside stimuli.

In the review, it has been planned to present first, the data from the available literature; an evaluation of these data will follow. The data are given in considerable detail because in most cases the number of subjects is small, and therefore averages are not of much significance. The methods are also given in detail because they are of great significance in the interpretation of the experimenter's results.

There is conflicting evidence concerning possible changes in basal metabolism with the aging process. Wolf (1929) in Cambridge, England, concluded that there was no evidence of a decreased metabolic rate resulting from advanced years. He based his conclusions on his

observations of the basal metabolic rates of three men and one woman in the age range 72 - 89. The subjects were observed in their own homes by the use of a Benedict student apparatus. In presenting these data Wolf included, as a comparison, the data on subject W.W.K., who had been observed by Stoner of Philadelphia.

Three different standards were used to evaluate the basal metabolic rates. The data are presented in Table I.

Table I.

BASAL METABOLISM OF FIVE SUBJECTS (Wolf)

Subject	Age	Weight	Height	Harris Benedict	Aub & DuBois	Dreyer
		Kgms.	Cm.	%	%	%
W.W.K.	89	60.3	154	+26.2	+2.9	+1.1
J.C.B.	89	58.8	172	+15	- +5.7	- +2.7
A.C.H.	74	71.3	178	+5	-5.5	-1
E.W.H.	72	59.4	186	+5	-9.2	+2.5
S.K.	79	41.6	149	+9	+3.2	+6.0

Although the energy of exchange of these subjects averaged about two calories per square meter per hour lower than the Aub-DuBois prediction standards, Wolf concluded that these results "do not afford any ground for assuming that the slope of the curve of Aub and DuBois for subjects between 20 and 70 years of age changes after the latter age is reached".

On the other hand, Lewis (1938) investigated the basal metabolism of 100 men from 40 to 90 years of age and concluded that basal metabolism decreases with age. In this study there were twenty men in each decade and two men aged 91, and one man 101 years. The following data are recorded in Table II.

Lewis concluded that the basal metabolism falls between the ages 40 and 89 years and that this fall may be expressed by the following equation: the calories lost per square meter per hour = 39.139 - 0.0678 X age. However from the mean values of succeeding decades, it was suggested by the author that the rate of decline may not be uniform but arrested between 50 and 79 years.

A Benedict-Roth portable apparatus was used in the Lewis study in most cases; a Sanborn apparatus in the rest. The subjects were not hospitalized or inmates of any institution. The first day the men were given a "rehearsal". The second morning the actual measurements were observed. The subjects remained in the hospital the night before their basal metabolic rates were recorded. An average of two tests were used if they agreed within six percent.

The other experimental work is presented in chronological order. Sonden and Tigerstedt (1895) studied subjects who ranged in years from seven to 84. These experimentors observed a negative correlation between age and gaseous exchange which indicated to them a decline in basal

Table II

BASAL METABOLISM OF MEN (Lewis)

AGE RANGE	NO. OF SUBJECT	MEAN CAL./ SQ.M./HOUR	CAL./KILO./ 24 HOURS
40-44	10	37.3	23.3
45-49	10	35.6	23.1
50-54	10	36.1	23.1
55-59	10	32.9	20.4
60-64	13	34.5	21.8
65-69	7	36.3	23.5
70-74	13	34.4	21.8
75-79	7	34.5	21.2
80-84	14	33.7	22.1
85-89	6	33.4	23.2
90-101	3	30.3	20.4

metabolism with increasing age. The data were calculated in terms of body surface.

Magnus-Levy and Falk (1899) presented data on observations of basal metabolic rates of fifteen "old men" and seventeen "old women". These early investigators concluded from their observations that metabolism remains essentially constant throughout adult life. However Harris and Benedict (1919) reinterpreted the original data of Magnus-Levy and Falk in terms of age and heat production expressed in calories per 24 hours. Harris and Benedict's correlation follows:

Correlation of age and heat production

Men and old men	$N^* = 15$	$r_{ah} =$	-0.238 ± 0.201
Women and old women	$N = 17$	$r_{ah} =$	-0.569 ± 0.111

Harris and Benedict conclude from the above negative correlation that Magnus-Levy and Falk "were in error considering that metabolism remains constant during adult life."

Zuntz and Loewy (1916,1918) reported metabolism measurements conducted on themselves over a period of twenty years.

Loewy found no change in his basal metabolic rate between the ages of 26 and 48 years. The basal metabolic rate of Zuntz showed essentially no change between the ages of 31 and 41 years, nor between the age of 41 and 63, he used 33.5 and 33.0 calories per square meter per hour, respectively.

*N= Number of subjects.

Basal metabolic rates of normal men and women were reported by Benedict _et al_ (1914). The universal respiration apparatus of Benedict and the bedsize calorimeter were used for the determination. The subjects were employees of the nutrition laboratory and people who came to the laboratory for the observations. They were people of "presumably" good health. Only nine subjects' values are presented in Table III: five women and four men.

One day's observations consisted of more than one 15 minute period. The cots upon which the subjects lay were so balanced that any movement was recorded on the kymograph. Only periods of complete repose were used in the averages.

Table III

BASAL METABOLISM OF WOMEN AND MEN (Benedict _et al_)

Age Years	Cal./Sq. M./Hour*	Cal./Kilo. /24 Hours	Age Years	Cal./Sq. M./Hour*	Cal./Kilo /24 Hours
Females			Males		
42	29.2	20.1	41	31.4	24.3
44	28.9	18.9	43	29.8	22.8
52	30.6	27.1	58	28.8	23.2
53	32.0	24.4	63	28.8	19.7
74	27.6	22.4			

DuBois (1916) presented in his Harvey Lecture a chart of heat production values for males and females expressed in calories per square meter per hour for various decades. These values were derived from observations made in the Nutrition Laboratory of the Russell Sage Institute.

* Calculated from Cal./Sq.M./24 Hours in original data.

The data are presented in Table IV.

Table IV.
BASAL METABOLISM OF MEN AND WOMEN (DuBois)

Age Years	Cal./Sq.M./Hour Females	Cal./Sq.M./Hour Males
20-50	36.9	39.7
50-60	32.7	35.2
77-83	——	35.1

No values were given for calories per kilogram per 24 hours; neither the number of subjects observed, nor the weights of the subjects was included.

At this same laboratory, Aub and DuBois (1917) observed the basal metabolic rates of six men between the ages of 75 and 85 years. The determinations were made in a bed-size calorimeter. The average calories used by five of the subjects equaled 35.1 calories per square meter per hour with an average deviation of about 1%. One of the subjects, whose heat production was extremely low, was not included in the averages on the basis of the statistical rule that the deviation from the mean was greater than four times the average deviation. The average heat production of 35.1 calories per square meter per hour was reported by the investigators to be 12% below average for men between ages of 20 and 50 years. The authors suggested that the reason for such low values might be attributed to the physical restrictions imposed upon the subjects in the Home for the aged and the Infirmary at Blackwell Island from which the

subjects were selected.

Harris and Benedict (1919) compiled comprehensive data on various investigations carried out in the Nutrition Laboratory and Deaconess Hospital in Boston, and in Battle Creek Sanitorium in Michigan during a period of two years. Only data on the age group 40 years and over are presented here. These groups of men and women represent the typical condition in the population defined as "normal" by the investigators. The "normality" of this series was judged "by comparison of their statistical constants with those of men and women in the population as a whole". That is, height, weight, surface area, pulse rate, body temperatures of the Harris-Benedict series were compared with statistical data available for these measurements and found to be mean values. The pertinent data consisting of observations on 11 men and 23 women follows in Table V.

The investigators further recorded the data in age ranges for both men and women. The data were recorded as follows in Table VI.

Harris and Benedict concluded from the graphical test of the linearity of regression that throughout the age range involved, the change in metabolism with age can be satisfactorily represented by a straight line. The deviations from the straight line were less when the values were expressed

Table V.

BASAL METABOLISM OF MEN AND WOMEN
(Harris and Benedict)

AGE	CAL./SQ.M./HOUR	CAL./KILO./24HOURS
	MALES	
40	38.4	26.0
41	34.9	24.3
41	36.2	21.7
43	31.7	22.8
43	39.1	28.1
45	32.1	22.2
57	39.1	26.2
58	32.8	23.2
61	34.7	23.4
62	34.4	21.3
63	35.4	19.7
	FEMALES	
41	31.8	20.6
42	36.9	20.1
43	34.9	32.1
44	36.6	18.9
44	28.9	16.7
44	32.8	19.7
45	40.6	26.8
50	32.8	23.8
51	29.2	16.9
51	28.0	20.1
52	31.6	26.4
52	29.4	15.1
53	36.4	24.4
56	30.3	18.4
57	29.3	20.4
58	34.4	21.0
60	29.2	19.6
61	32.2	23.0
62	31.5	24.0
66	30.1	20.6
73	33.8	19.8
74	30.2	22.4

Table VI.

BASAL METABOLISM OF MEN AND WOMEN

IN DECADES (Harris and Benedict)

AGE RANGE	NO. OF SUBJECTS	MEAN CAL./SQ.M./ 1 HOUR *	MEAN CAL./KILO./ 24 HOURS
	MEN		
40-44	5	36.2	24.6
45-49	1	32.1	22.2
50-54	-	- - -	- - -
55-59	2	36.0	24.7
60-64	3	34.8	21.5
65-69	-	- - -	- - -
70-74	-	- - -	- - -
	WOMEN		
40-44	6	33.7	21.4
45-49	1	40.6	26.8
50-54	6	32.2	21.1
55-59	4	30.9	19.2
60-64	3	32.0	22.2
65-69	1	30.1	20.6
70-74	2	32.0	21.1

* Calculated from original data.

Table VI.

[illegible] Metabolism of [illegible]

in [illegible] (Harris and Benedict)

Age group	No. of cases	[illegible]	[illegible]
		Men	
40-44	5	30.2	24.6
45-49	1	33.1	22.2
50-54	-	---	---
55-59	2	35.0	24.7
60-64	3	34.8	21.5
65-69	-	---	---
70-74	-	---	---
		Women	
40-44	[illegible]	33.7	[illegible]
45-49	1	[illegible]	[illegible]
50-54	6	32.2	21.1
55-59	4	30.9	19.2
60-64	3	32.0	22.2
65-69	1	30.1	[illegible]
70-74	2	[illegible]	[illegible]

* [illegible]

as calories per square meter per hour than as calories per kilogram for 24 hours. The gross correlation between heat production and age was a negative correlation of -0.31 for men and -0.20 for women which the authors interpreted as a decrease with age. They expressed the actual decrease in daily heat production per year as approximately 7.15 calories in men and 2.29 calories in women. The decrease in calories per square meter equaled 3.60 calories per 24 hours per year.

Boothby and Sandiford (1922) from Mayo Clinic, Rochester Minnesota, studied 8,614 individuals of both sexes who were classed as normal in that these subjects had no known diseases which might elevate the basal metabolic rates. The open-circuit method was used. Analysis of expired air was made by the Haldane gas analysis apparatus. Only the first observation on any one day was used in the average recorded unless the subject was "obviously restless or under nervous tension". The ages of the subjects ranged from 21 to 67 years.

The data presented in Table VII were for females with age range of 46 to 67 years.

Lusk and DuBois (1924) reported observations on basal metabolism measurements on themselves over a period of 11 to 14 years. The data are presented as follows in Table VIII. Some of the determinations were done in the Sage Calorimeter, others with a Benedict-Roth appartus.

Table VII.

BASAL METABOLISM OF WOMEN

(Boothby and Sandiford)

AGE	CAL./SQ.M./HOUR *	CAL./KILO./24 HOURS *
46	35.9	22.6
46	34.4	19.0
48	33.1	20.6
50	38.4	26.8
50	34.6	20.4
52	33.6	17.8
52	35.7	20.6
52	35.6	27.0
53	36.8	24.9
53	38.8	29.9
55	32.7	24.5
55	33.7	20.9
62	36.4	26.4
67	36.8	27.1

* Calculated from original data.

Table VIII

BASAL METABOLISM OF DUBOIS AND LUSK OVER A PERIOD OF YEARS

AGE	CAL./SQ.M./HOUR	CAL./KILO./24 HOURS
	DuBois	
30	40.6	25.15
31	38.4	24.02
32	37.2	22.9
33	38.8	23.8
38	34.4	21.1
39	36.7	22.6
41	37.0	21.6
	Lusk	
40	42.8	25.0
43	41.8	24.9
54	32.7	19.9

The authors attributed the great change in Lusk's basal metabolism measurements in the interval of fourteen years to his less vigorous habits in the latter part of his life.

MacLeod and Rose (1925) from Columbia presented a study on basal metabolic rates of 92 women between the ages of 20 and 50, on whom 136 determinations were observed. The subjects were graduate students and faculty wives who continued their daily habits. A Benedict portable respiration apparatus was used. Only two age ranges will be presented in Table IX.

Table IX.

BASAL METABOLISM OF WOMEN (MacLeod and Rose)

Age	Number of Subjects	Cal./Sq.M./Hour
30-39	31	34.0 ± 0.29
40-49	13	31.3 ± 0.57

Benedict (1928)[a] from the Nutrition Laboratory of the Carnegie Institution of Washington in Boston, observed basal metabolism on 27 men and 33 women. The men's ages ranged from 21 to 89 years. The women's ages ranged from 18 to 58 years. The same technique was not used throughout the entire experimental periods, but all equipment was tested by alcohol check. Only the pertinent data are presented here in Table X.

Benedict (1928)[b] observed basal metabolie rates on three men over a period of 11 to 18 years. Again the techniques were varied over the long interval of the experiment. The

Table X

BASAL METABOLISM OF MEN AND WOMEN (Benedict)[a]

AGE	OBSERVATIONS	CAL./SQ.M./HOUR	CAL./KILO./24 HOURS
		Men	
50	2	36.8	20.9
60	1	35.5	19.7
60	12	35.9	24.9
89	2	35.5	22.3
		Women	
48	2	31.7	19.2
49	3	31.2	19.8
50	2	34.9	18.1
50	2	32.3	19.5
50	2	32.9	18.6
51	2	33.6	16.5
58	9	33.3	21.8

first man was observed for 16½ years. His average heat production for that period equaled 1330 calories per day. The second man was studied for a period of 19 years. Figures for one observation from each year are presented. The third man was observed for a period of 18½ years. Figures for one observation from each year are presented. The data follow in Table XI.

Benedict and Meyer (1932) observed the basal metabolism of 23 women between the ages of 66 and 86 years. The subjects were selected from the Massachusetts Home in Boston and none of the women were bedridden. The measurements were made under basal conditions beginning at 7:00 or 7:30 a.m. and continuing until three or four "well-agreeing" values were obtained. These observations were made on not less than two different days with time intervals not too great. A helmet was used in place of the nose clip and mouthpiece attachment in connection with a Benedict-Roth respiration apparatus. The data were recorded as follows in Table XII.

The authors concluded that all the women 78 years and over had a total heat production of approximately 1000 calories per 24 hours, and that a clinician might accept this value without too much error.

Table XI.

BASAL METABOLISM OF THREE MEN OVER A PERIOD OF YEARS (Benedict)[b]

Age	Cal./Sq.M./Hr.	Cal./Kilo./24 Hrs.
	H.M.C. 1911-1927	
42	31.6	22.6
48	32.3	22.8
50	30.4	22.3
59	30.9	22.0
	F.G.B. 1909-1928	
38	38.2	22.6
40	36.4	21.6
40	34.8	20.6
43	35.4	20.7
44	36.2	21.1
46	35.3	20.8
47	35.0	21.1
49	33.7	20.3
49	33.9	21.1
50	33.7	20.3
52	39.2	23.3
53	33.9	20.7
54	33.2	20.4
56	32.2	19.9
57	32.1	19.5
	T.M.C. 1909-1927	
30	38.3	28.5
31	37.3	28.2
34	37.4	27.8
34	35.1	26.6
35	35.9	26.9
39	35.8	27.5
41	32.5	24.6
45	31.2	22.8
48	33.1	24.3
49	28.9	21.6

Table XII

BASAL METABOLISM OF WOMEN (Benedict and Meyer)

SUBJECT	AGE	CAL./SQ.M./HR.	CAL./KILO./24 HR.
I	66	25.8	18.5
II	68	33.3	19.2
III	70	33.7	19.4
IV	70	31.7	21.2
V	71	35.7	20.8
VI	71	29.7	18.0
VII	71	31.3	19.9
VIII	71	30.2	20.7
IX	73	33.2	20.6
X	74	29.7	17.8
XI	74	27.2	21.0
XII	76	33.3	23.3
XIII	77	29.6	25.1
XIV	78	31.2	23.4
XV	79	26.5	15.2
XVI	81	30.1	23.7
XVII	81	26.9	15.5
XVIII	84	20.0	20.2
XIX	84	30.8	23.8
XX	84	33.7	24.0
XXI	84	29.3	21.4
XXII	84	25.7	15.2
XXIII	86	28.8	19.0

Kise' and Ochi (1934) reported basal metabolism of 94 normal Japanese between the ages of 50 and 93 years; 50 females and 44 males. They observed a 3-5 percent decrease in basal metabolism for each 10-year period. They modified DuBois' surface area formula because the Japanese have different body proportions. The pertinent data follow in Table XIII.

Differences between the 50 and 80 year group equaled a 3.99 calorie decrease in men (11%) and 3.65 (11%) decrease in women. The authors pointed out that the decrease was gradual.

Benedict and Root (1934) observed the basal metabolism of Mr. Seth Lincoln, a man 91 years old, and compared their observations with similar observations on Sir James Crechton Browne, aged 89 years, by Wolf of Cambridge, and observations on Dr. W. W. Keen, aged 89 years, by Stoner of Philadelphia. The data were as recorded in Table XIV.

Matson and Hitchcock (1934) studied basal metabolisms of eight women and 14 men with an age range from 74 to 106 years. The women were selected from Saint Anthony's Hospital, Home for the Aged section, at Columbus, Ohio, but none of them was under medical care. All determinations were made by Benedict-Roth respiration apparatus. The following data on the women are presented in Table XV.

Table XIII.

BASAL METABOLISM OF MEN AND WOMEN IN DECADES (Kise' & Ochi)

Age	No. of Subjects	Cal./Sq.M./Hr.	Cal./Kilo./24 Hrs.
		Males	
50-59	13	36.0	25.9
60-69	15	34.9	25.6
70-79	10	33.2	29.0
80-89	5	32.1	24.1
		Females	
54-59	8	34.0	23.8
60-69	16	33.2	24.8
72-78	18	31.9	25.1
80-86	8	30.4	24.3

Table XIV.

BASAL METABOLISM OF MEN (Benedict and Root)

Subject	Oxygen Consump./Min.	Cal./Sq.M./Hour *	Cal./Kilo./24 Hours*
Seth Lincoln 91 years	147 cc. 151 150 165		
Ave.	153.	26.2	18.3
Sir James Crechton-Browne 89 years			
Ave.	192	34.5	23.8
Dr. W. W. Kean 89 years			
Ave.	193	35.5	22.3

* Calculated from original data.

Table XV.

BASAL METABOLISM OF WOMEN (Matson and Hitchcock)

Subject	Age	Number of tests	Cal./Sq.M. /Hour	Cal./Kilo./ 24 Hours
1	106	8	21.2	18.2
2	91	3	26.9	18.2
3	84	2	27.1	23.5
4	83	3	26.1	16.8
5	83	3	34.8	29.2
6	80	2	28.3	15.8
7	80	3	29.9	16.1
8	77	3	26.3	15.8
Ave.	86		26.6	17.8

If the 106 year old woman and the subject who had such high heat production values were excluded from the averages, the other six women had an average basal heat production of 28.25 calories per square meter per hour, or 1,047.6 calories per 24 hours. The authors concluded that no significant correlation existed between heat production and age. Matson and Hitchcock reported little evidence of a correlation between the basal heat production and the degree of senility. The estimation of degree of senility was arbitrary; a rating of one was given to a woman displaying the least degree of senility, and ratings of two, three, and four denoted increasing degrees of senility.

Boothby, Berkson and Dunn (1936) observed basal metabolic rates of 639 males and 828 females selected from the Mayo Clinic clientele since 1917. The subjects were either Mayo Clinic employees, professional and non-professional, or patients at the clinic. These subjects were free from any diseases known to affect basal metabolism.

The data were composed of the first determination for each individual unless the patient was restless, under obvious nervous tension or had an elevated temperature. When several observations were made on different days, only the first observation for any day was used. Only the pertinent data are presented in Table XVI. The gasometer or open-circuit method was used with duplicate analysis of the expired air.

Table XVI

BASAL METABOLISM OF MEN AND WOMEN (Boothby, Berkson & Dunn)

Male			Female		
Age	No. Of Subjects	Cal/Sq.M. /Hour	Age	No. of Subjects	Cal.Sq.M. /Hour
40	11	37.9	40	13	35.4
41	14	37.8	41	13	35.4
42	7	37.7	42	12	36.1
43	14	37.2	43	15	35.2
44	15	39.0	44	11	36.8
45	9	37.7	45	12	35.0
46	11	36.5	46	12	35.7
47	8	38.5	47	6	34.9
48	5	35.0	48	11	33.8
49	9	37.4	49	8	35.1
50	9	36.9	50	16	33.9
51	8	37.3	51	9	32.6
52	15	36.3	52	13	34.5
53	3	35.7	53	14	34.4
54	6	35.9	54	12	34.1
55	5	35.5	55	12	33.2
56	6	35.9	56	6	32.9
57	6	34.7	57	10	32.8
58	3	37.1	58	7	33.9
59	6	38.0	59	6	34.3
60	5	35.2	60	6	34.7
61	3	36.9	61	2	32.4
62	-	—	62	7	34.1
63	2	37.3	63	3	30.7
64	3	37.8	64	-	--
65	-	—	65	4	35.1
68	-	--	68	11	33.3

The authors expressed the opinion that the sample presented was indicative of the population trend of basal metabolism in relation to age.

McKay and Patton (1936) reported basal metabolism figures for a group of 73 women ranging in age from 35 to 70 years. The women included professors' wives and faculty members of Ohio State University. All continued their usual work routine during observation. The Benedict-Roth respiration apparatus was used. Each test consisted of two-10 minute observations. Tests were repeated once and sometimes twice. The lower figure of the two sets was used. The data are presented in Table XVII.

Table XVII.

BASAL METABOLISM OF WOMEN (McKay and Patton)

Age Range	No. of Subjects	Cal./Sq. M./Hour	Cal./Kilo /24 Hours
30-39	18	34.0	21.7
40-49	25	33.6	21.1
50-59	19	31.6	19.5
60-69	10	30.3	20.4
70	1	33.0	16.8

From the above data, it may be seen that the basal metabolism for the age group, 30-39, was similar to that for the group aged 40-49 years. In the next two decades (50-69) a decrease in heat production was observed. The authors concluded that the basal metabolism of women remains uniform until 50 years of age, and that after 50 years, the heat production declines.

Magnus-Levy (1942) reported basal metabolism determinations made on himself after an interval of 50 years. The investigator also published data obtained for four other professors over several years' period. The data are presented as follows in Table XVIII.

Table XVIII.

BASAL METABOLISM OF FIVE PROFESSORS (Magnus-Levy)

Subject	Age-Years	Cal./Sq.M./Hour
Zuntz	41	33.6
	70	30.2
Magnus-Levy	26	38.1
	76	31.5
Lusk	44	42.8
	58	32.7
Benedict	38	38.2
	57	32.7
DuBois	30	38.1
	58	34.5

From the literature it may be seen that most authorities believe that basal metabolism decreases as age increases. However a few have found evidence that the basal metabolic rate remains constant throughout adult life. In the above papers Magnus-Levy et al (1899), Zuntz and Loewy (1916-1918) and Wolf (1929) found little evidence of change in basal metabolic rates with advance in years. However Harris and Benedict (1919) reinterpreted the data compiled by Magnus-Levy and indicated a negative correlation between heat production expressed in calories per 24 hours and age.

Most of the other investigators seem to believe that basal metabolism decreases with age. However, Sonden and Tigerstedt (1895), Benedict et al (1914), Aub and DuBois (1917), Benedict (1928), Benedict and Root (1934) based their conclusions on a relatively small number of subjects in the later decades of life. DuBois (1916), Harris and Benedict (1919), Boothby and Sandiford (1922), MacLeod and Rose (1925), Boothby et al (1936), McKay and Patton (1936), Lewis (1938), and Kise' and Ochi (1934), observing Japanese subjects, reported data compiled from larger numbers of subjects. Lusk and DuBois (1924), Benedict (1928), and Magnus-Levy (1942) reported observations on a limited number of the same individuals, but made successive observation over a period of 20 and 50 years.

There has not been as much experimental work with older women as with men. The investigators who have reported observations on women were Magnus-Levy et al (1899), Benedict et al (1914), Harris and Benedict (1919), Boothby and Sandiford (1922), MacLeod and Rose (1925), Benedict (1928), Benedict and Meyer (1932), Kise' and Ochi (1934), Matson and Hitchcock (1934), Boothby et al (1936) and McKay and Patton (1936). The data on women is summarized in Table XIX. These studies were largely cross-sectional, observing a number of individuals at a single age level. No linear studies were found in the examination of the available literature.

Table XIX.

SUMMARY OF THE REVIEW OF LITERATURE ON BASAL METABOLIC
RATES OF WOMEN IN LATER MATURITY

								nome under medical care	
Boothby, Dunn and Berkson (1936)	103 67 13	37.5	33.7	24.3		31.8	Open circuit gasometer	Clinic clientele and employees of Mayo clinic, profess-ional, and non-pro-fessional	First observ-ation if subject not restless or had elevated temperature
McKay and Patton (1936)	25 19 10 1	33.6	31.6	30.3	33.0	32.2	Benedict-Roth	Professor's wives and faculty of Ohio State University	Two ten-minute ob-servations on one day. Lower set used

[illegible]

[illegible]

[illegible]

[illegible]	[illegible]	[illegible] TOT [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible] Total	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]

The selection of data, selection of subjects and experimental conditions varied considerably in these studies on basal metabolism of women and this variance raises some questions on the conclusions which have been made. Many differences appear in the different investigator's selection of data which they considered reliable. Benedict et al (1914) recorded only observations in which each subject was in complete repose as described above. Perhaps by discarding observations other than those of complete repose the true pattern of the basal metabolic rates of the subjects was lost. Boothby et al (1922, 1936) recorded only the first observation unless it became evident that basal conditions were not being maintained. Has Boothby presented the complete basal metabolic pattern of the subjects by using only the first observations? Benedict and Meyer (1938) made observations until three or four "well-agreeing periods" were secured. McKay and Patton chose the lower of two sets of observations in recording heat production values. In Pittman et al (1946) study, 10 college girls showed a variation of 4 to 27 calories per square meter per hour in basal metabolism during the period of a year. Although older women may have endocrine changes differing from these younger women, cannot the older women be expected to have comparable variations in basal metabolism? Therefore, is the use of the first observations, the

lower observations, or the well-agreeing observations perhaps advisable?

In some of the other studies the conditions were less explicitly described. Kise' and Ochi (1934) stated that they followed accepted procedures in choosing their data. MacLeod and Rose (1925) and Magnus-Levy _et al_ (1899) did not define clearly any system of selection.

In the selection of subjects there also appears a wide variation among investigators. Harris and Benedict (1919) used only subjects who were considered "normal" in regard to physical measurements in that each subject's height, weight, chest circumference, pulse rate, blood pressure and oral temperature represented mean values compiled from a large population. This study was conducted to present "normal" basal metabolic rates of individuals in different age ranges, but are these values determined from such rigidly selected normals a fair standard for comparison to individuals in an age group in which a large proportion of the population, although not clinically ill, would fail to meet Benedict's standards of "normal". (National Health Survey, 1935 and 1936).

Benedict and Meyer (1928) and Matson and Hitchcock (1934) selected their subjects from homes for the aged. Although none of the subjects were bedridden, they perhaps should be considered "hospital normals" and therefore differing from individuals continuing an active life. Kise' and

Ochi (1934), MacLeod and Rose (1925) and McKay and Patton (1936) observed large numbers of subjects in the later decades of life who continued their usual daily routine. There appears to be some variation in the length of time of the observations. Benedict and Meyer made fifteen minute observations until three or four "well-agreeing" periods were secured. Could the factor of fatigue from such long observations influence the values of basal metabolism recorded?

Another point of criticism of the data in the literature is that although the correlation of basal metabolism and age has been shown by some investigations to be statistically significant, the practical significance of the data is questionable. For example, Harris and Benedict (1919) reported an annual decrease of 2.29 calories per day. The practical significance of two calories in a daily consumption of 1,600 does not seem very vital.

EXPERIMENTAL PROCEDURE

The basal metabolic rates of 20 women were observed. Each woman was brought to the laboratory on three different days. All subjects were brought by car but subjects XIV and XVI. There was no definite time limit set between the first and third test days, but in 15 cases the three days came within a period of one month. In the remaining five cases the three test days came within a two month period. On each test day two observations were made on each subject; a period of not less than 10 minutes elapsed between these two observations.

A Benedict-Roth portable respiration apparatus was used in making the determinations. The nose-clip and mouthpiece attachments were used. The equipment was checked periodically for leaks by the use of a counterbalanced weight. Room temperature readings were recorded by the use of a thermometer attached to the metabolism equipment. Barometric pressures were read from a United States Weather Bureau type mercury barometer which hung in the testing room. The room where the determinations were made was a large one on the second floor of the Home Economics Building. It had three large windows facing south over which venetian blinds could be drawn to produce semi-darkness. The temperature of the room was kept relatively constant as the heat supply to the room was controlled by a direct line independent of

the rest of the building. At the end of the room near the windows there were two spring cots with mattresses and pillows on which the subjects lay during the resting and test periods. Two doors led from the room, one to the adjoining research laboratory and the other door to the hallway. Directly adjoining the metabolism room was a room which contained a water still and sterilizer which made some noise when in operation. Conversation and footsteps were indistinct and not disquieting when the two doors of the metabolism room were closed. Loud conversation and interruptions were controlled by "Do Not Disturb" signs posted on the outside of the doors of the metabolism room.

Usually one subject was observed alone, but circumstances necessitated in some instances the making of a determination on one subject while another was resting. However, both subjects were forewarned of talking during the testing of the other subject or during the rest period before the test.

Each woman was instructed before coming to the laboratory to eat nothing after supper and secure approximately eight hours of rest the night before the test and on the morning of the test no food or fluid was allowed. The subjects were brought to the laboratory between 8:00 and 8:30 a.m.. Upon arriving at the laboratory the subject was

instructed to rest or sleep, as she chose, for a period of one-half hour. Since the subjects were unfamiliar with metabolism equipment, a brief explanation of the use of the mouthpiece and noseclip was made on the day of the first test. The pulse rate of the subject was then taken, the mouthpiece inserted, the subject was allowed to breathe the room air for a period of a few minutes at the end of which time the valve was closed and the testing begun. One observation consisted of an eight-minute period, the first two minutes of which were considered an "adjustment" period; the actual determinations were made on the six-minute period following. At the end of the first eight-minute testing period the noseclip and mouthpiece were removed and the subject was allowed at least a ten-minute rest period before the second observation was made.

The same procedure ensued as in the first observation except the pulse rate was recorded during the first two-minute adjustment period of the eight-minute observation. At the end of the second observation the subject was weighed and measured, fully clothed except for shoes and other heavy outer garments, and the subjects' oral temperature was taken.

Subjects: The twenty women observed were from the ages of 48 to 77 years inclusive. The only criterion used in the selection of the subjects of this study was age;

only women over 40 years were chosen. Sixteen of the women were selected from a list obtained from a random sample of the population of women over 40 years of age in Lansing. The remaining four subjects were friends of the author. At the time of selection the women had been interviewed once by a member of the Foods and Nutrition staff at which time physical and dietary histories were taken. Fourteen of the subjects were later given physical examinations by the U. S. P. H. S. Mobile Unit. Fifteen of the subjects were active housewives. Subjects XIV, XV, and XVIII lived with relatives and shared household responsibilities. Subjects IV and XVI maintained a household besides full-time jobs. Nineteen of the subjects had been residents of Michigan for many years. Subject XIV moved to Michigan from Nebraska this year. Seventeen of the subjects had had at least one child.

The physical examination reports indicated that four of the subjects had systolic blood pressure readings over 200 mm. The blood pressure readings of the other 10 subjects were 116 mm. to 185 mm. inclusive. These physical examination reports also showed that Subject VIII and X had enlarged thyroid glands. Subjects V and VII had had thyroidectomies in 1923 and 1930 respectively. Of these subjects, VII had not taken thyroxin; Subject V had taken one grain daily.

Selection of Data: All observations were included in the data with the following exceptions. In three cases one observation was discarded as atypical in that the oxygen consumption line was curved. In four cases one observation was discarded because it seemed that the readings were either too high or too low to be a physiological variation.

GENERAL OBSERVATIONS AND DISCUSSION

The individual values expressed as calories per square meter per hour are given in Table XX. The average values, grouped in decades, are presented in Table XXI. The averages of the three days' observations on the subjects appear in column 3 of the table XXI. Column 4 presents the averages of the second and third day's observations only. Although in the typical clinical procedure, values are usually accepted from the first day's observations, in this study the first day's observations were considered a practice period because the subjects, unaccustomed to basal metabolism procedure, might have been under nervous tension and not comfortably relaxed. In the discussion of the data the averages of the second and third days only will be used. However, it appears that the first test was fairly reliable since the difference between the average of all determinations and the average of the second and third day was so small as to be insignificant as seen in Table XXI.

In Graph I, calories per square meter per hour and age in years are given. It might be concluded from Table XXI. that there is a drop in the basal metabolic rate of women from the age of forty through seventy-nine, but an examination of the individual variations in Graph I shows such an assumption to be questionable. For example, in the 70-79 year age range Subject XVIII had a low metabolic rate when

Table XX.

BASAL METABOLISM OF WOMEN IN LATER MATURITY

SUBJECT	AGE	HEIGHT cm	WEIGHT kg	AVE. SURFACE AREA (Dubois)*	CAL/SQ.M/HOUR Test I	CAL/SQ.M/HOUR Test II	AVE. OF ALL Det.	AVE. 2nd & 3rd DAY	TOTAL CAL. PER DAY	CALORIC INTAKE
I	48	159.5	65	1.65	37.6 29.2	36.0 36.3 30.6	33.9	32.0	1,342	2,479
II	49	158	42.4	1.36	37.3 34.4 29.1	39.2 36.4 32.8	34.9	33.2	1,139	2,503
III	50	165	105.6	2.10	33.1 32.4 28.5	32.2 32.8 20.6	31.6	31.1	1,593	1,664
IV	50	168	77.2	1.85	35.6 35.4 36.2	32.8 30.7 32.0	33.8	33.6	1,500	
V	52	164	60.0	1.63	30.1 28.8 30.8	26.4 29.3 30.4	29.3	29.8	1,146	
VI	52	163	90.9	1.90	26.4 40.0	30.4 39.1	33.9	39.6	1,538	2,157
VII	52	163	94.0	1.97	33.4 34.3	33.8 32.9 34.4	33.8	33.9	1,598	1,460
VIII	56	154	53.8	1.50	40.5 39.3 38.6	41.7 39.8 36.9	39.4	38.6	1,418	2,154
IX	57	164	65.1	1.69	36.9 51.0	39.9 32.3 44.4	40.9	41.2	1,659	2,183
X	59	149	59.5	1.52	38.5 36.4	38.2 39.0 35.8	37.6	37.4	1,372	1,881
XI	60	158.5	78.5	1.79	36.1 29.8 32.9	29.8 36.2 30.1	32.5	32.3	1,381	1,332
XII	62	162	75.4	1.82	38.9 39.8 39.4	43.2 38.3 37.5	39.5	38.8	1,735	1,942
XIII	63	161	71.5	1.83	32.2 23.1 32.2	31.7 26.7 31.7	30.9	30.2	1,290	2,027
XIV	63	158	69.1	1.70	39.7 34.0 32.2	37.7 33.0 36.8	35.6	34.0	1,452	
XV	64	166	51.4	1.55	41.4 35.1 33.4	39.2	36.8	34.5	1,283	1,173
XVI	64	175	74.9	1.92	33.7 33.6 32.7	35.1 34.6	33.3	32.7	1,534	
XVII	68	169	68.0	1.76	34.1	31.8	33.9	33.8	1,448	1,483
XVIII	73	163	69.7	1.72	32.1 35.2 31.9 25.9	35.5 29.5	29.7	27.9	1,233	1,380
XIX	74	168	66.3	1.73	34.6 34.8 36.6	25.9 31.1 32.8 34.1	34.0	34.5	1,412	1,338
XX	77	172.5	74.3	1.86	37.1 35.4 33.9	31.0 34.1 30.7	33.7	33.5	1,504	1,575

* Modified by Boothby and Sandiford (1929)

Table XXI.

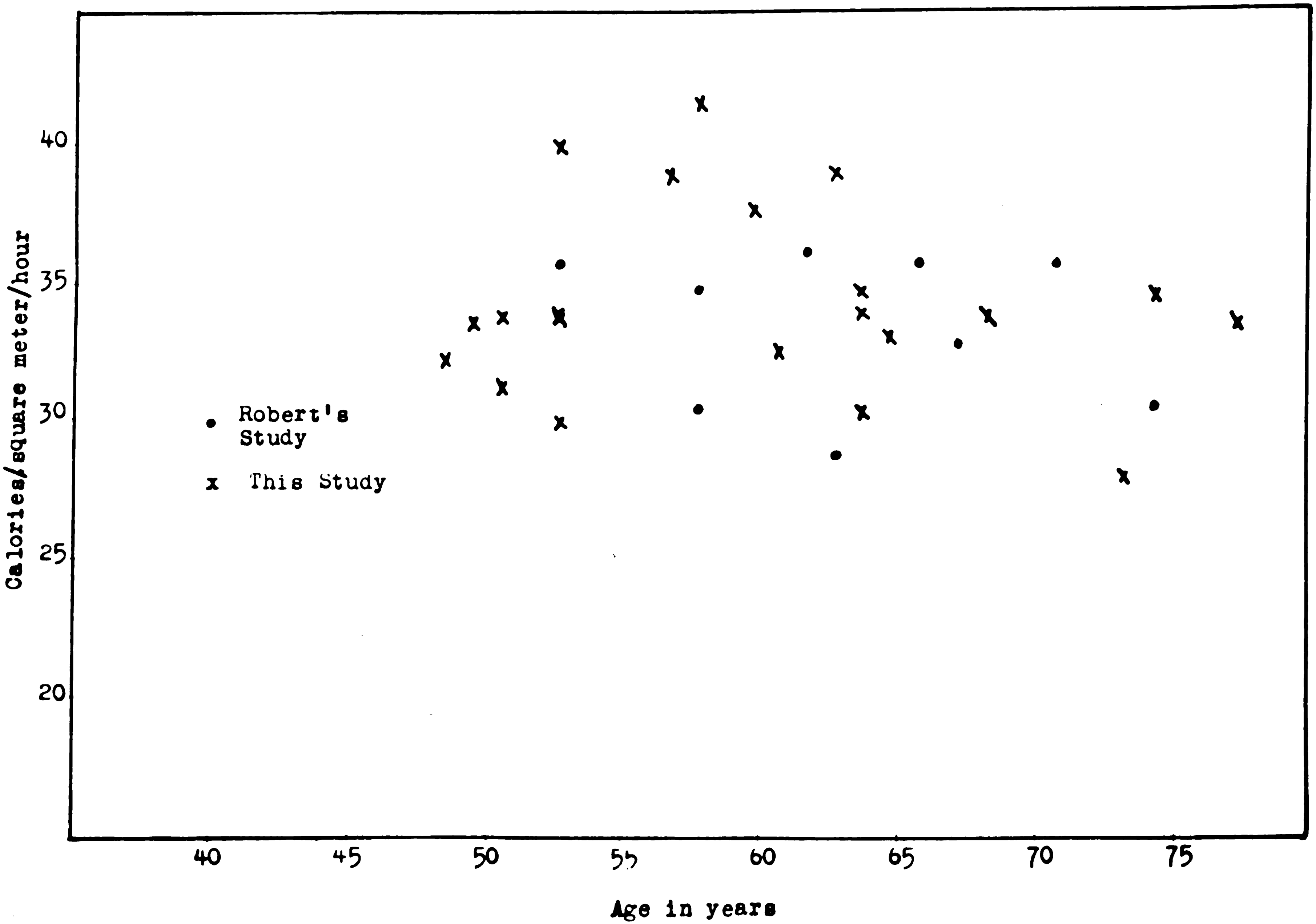
BASAL METABOLISM OF OLDER WOMEN IN DECADES

AGE RANGE	NO. OF SUBJECT	AVE. OF ALL DET. CAL./SQ.M/HOUR	AVE. OF SECOND & THIRD DAY CALS./SQ.M/HOUR
40-49	2	34.4	32.6
50-59	8	35.0	35.6
60-69	7	34.3	33.7
70-79	3	32.4	31.9

		CAL./SQ.M/HOUR
Ave. of all subjects:	All Det.	34.3
Ave. of all subjects: and Third Day	Second	34.1

Graph I

BASAL METABOLISM OF WOMEN IN LATER MATURITY - SECOND AND THIRD DAY AVERAGES



compared to Subject XIX and Subject XX. It is because of the low value of basal heat production for Subject XVIII that the average of the three women in this age range was relatively low. If the calories per square meter per hour of Subject XIX and Subject XX were averaged, the value for this age range would then be 34.0 calories rather than 31.9 calories. Obviously, three subjects in this age range is too small a number from which to draw a reliable conclusion, but it would indicate that low basal metabolic rates should not necessarily be associated with women in the 70-79 year age range. Subject XVIII, XIX and XX seemed to be good representatives of active women over seventy years of age. Subject XVIII had only partial responsibility for her household. A daughter and granddaughter lived with her and shared the household tasks, and laundry was sent outside the home. This subject appeared younger than her chronological age; she was an agile individual with only slight degrees of stiffness in body movements. Subject XIX did all her own housework and kept two roomers. She was an extremely agile individual. For instance, this summer she canned cherries which she had picked from a tree in her backyard. She appeared much younger than her 74 years as her hair was only slightly grayed around the temples. Subject XX also did all her own work for her husband and herself, besides keeping a roomer. The subject also seemed much younger than her actual age and her body movements were comparable to a younger individual.

The majority of investigators have reported for this age range values lower than 34.0 calories, which is the average basal heat production of Subjects XIX and XX. Benedict and Meyer (1932) reported 31.0 calories for 13 subjects in the 70-79 year age range. However the subjects were "hospital normals" and perhaps should not be compared to active women. Matson and Hitchcock (1934) found a value of 26.3 calories per square meter per hour for one woman in the 70-79 age range, but again the subject was a "hospital normal ". McKay and Patton (1936) reported an average value of 33.0 calories for subjects who were active individuals; this value represented the lower set of observations. Kise' and Ochi (1934) presented an average of 31.9 calories per square meter per hour for 18 Japanese women in the 70-79 year age range.

It is interesting to note in Graph I that relatively high basal metabolic rates appear in the age range of 52 to 62 years, inclusively. The calories per square meter per hour were 39.6, 33.9, 38.6, 41.2, 37.4, 32.3, and 38.8 respectively, for the eight women in this age range, or an average heat production of 37.4. The data from the Roberts et al (1948) study have been superimposed upon the data of the present experiment in this graph and it may be noted that the relatively high values found in Roberts' study appear in the 50-60 year group, also. From the data on women

reported by Benedict et al (1914), the values of heat production on the whole are smaller than the ones here recorded, but again the relatively higher values are found in the two subjects 52 and 53 years of age. Benedict (1928) reported figures in the 50-58 year range that were comparatively higher than those in the preceding age range. Kise' and Ochi (1934) also published values that were higher in the fifth decade. This rise does not seem to appear in the basal metabolic rates of men in this decade. Is this rise in basal metabolism in the age range 50-60 years a physiological pattern usually followed by women of this age? Since the menopausal change in women is generally a more pronounced one in women than the corresponding change in men, it is logical to expect the basal metabolism to be dissimilar. Is an adjustment period following the endocrine change that may accompany menopause the reason for the rise in basal metabolic rate in women? If so, this fact should be taken into consideration in recommending food needs of women in this age range.

The common method of reporting basal metabolism data has been calories per square meter per hour. Table XX gave average calories per square meter per hour and total calories per day. However there seemed to be little evidence that this method was the best expression for people in later maturity.

Harris and Benedict (1919) stated that the correlation between body weight and total heat production was high: "in adults a difference of one kilogram in body weight is followed by an average difference of 8.2 calories in heat production in women."

In Table XX it may be seen that the women with higher weights have higher basal heat production when values were expressed as total calories per day. Subjects III and VII, whose weights were 106 and 94 kilograms respectively, have total heat production of 1,593 and 1,598 calories per 24 hours, whereas Subjects II and XV, weighing 42 and 51 kilograms, have a heat production of 1,139 and 1,283 calories per day, respectively. For this reason the data of this study has been reported in both calories per square meter and calories per kilogram per twenty four hours in Table XXII.

The data expressed as calories per kilo were grouped in decades in Table XXIII. There was a slight negative correlation of -.02 between calories per kilogram per 24 hours and age. However the relationship of body weight and heat production (Harris and Benedict, 1919) perhaps should not be applied to individuals who were overweight. Short and Johnson (1936) have criticized the comparison of the metabolism of normal individuals with the metabolism of obese individuals. Subjects III, VI and VII are 75%, 40% and 59% over-

Table XXII.

COMPARISON OF HEAT PRODUCTION WITH HEIGHT, WEIGHT,
PULSE RATE AND BLOOD PRESSURE

SUBJECT NUMBER	AGE YEARS	SECOND AND THIRD DAY AVERAGE CALS./SQ.M/HOUR	SECOND AND THIRD DAY AVERAGE CALS./KILO./24 HOURS	CALS./CM./24 HOURS	PULSE RATE	BLOOD PRESSURE	% OVER WEIGHT*
I	48	32.0	19.4	7.98	57	120/80	+13%
II	49	33.2	25.7	6.93	66	116/60	-25%
III	50	31.1	14.8	9.48	64	152/98	+75%
IV	50	33.6	19.3	8.88	60	——	+21%
V	52	29.8	19.5	7.12	60	——	Normal
VI	52	39.6	21.1	11.0	68	140/90	+40%
VII	52	33.9	16.9	9.82	55	——	+59%
VIII	56	38.6	25.9	9.03	68	170/90	Normal
IX	57	41.2	25.8	10.2	70	128/70	+7.5%
X	59	37.4	22.8	9.16	72	200/120	+15%
XI	60	32.3	17.6	8.73	61	230/175	+31%
XII	62	38.8	21.7	10.42	62	210/90	+32%
XIII	63	30.2	17.5	7.77	70	138/70	+22%
XIV	63	34.0	20.2	8.76	72	——	+23%
XV	64	34.5	25.2	7.76	74	140/90	-17%
XVI	64	32.7	19.2	8.61	66	——	+7.3%
XVII	68	33.8	20.5	8.50	67	185/90	+7.1%
XVIII	73	27.9	16.7	7.13	53	160/70	+16%
XIX	74	34.5	21.7	8.54	58	200/110	+3.5%
XX	77	33.5	20.2	8.72	56	168/80	+13%

* From Average Height and Weight Table in Chaney and Ahlborn "Nutrition", 3rd Edition, page 3.

Table XXIII.

COMPARISON OF WEIGHT AND CALORIES

PER SQUARE METER PER 24 HOURS AND AGE

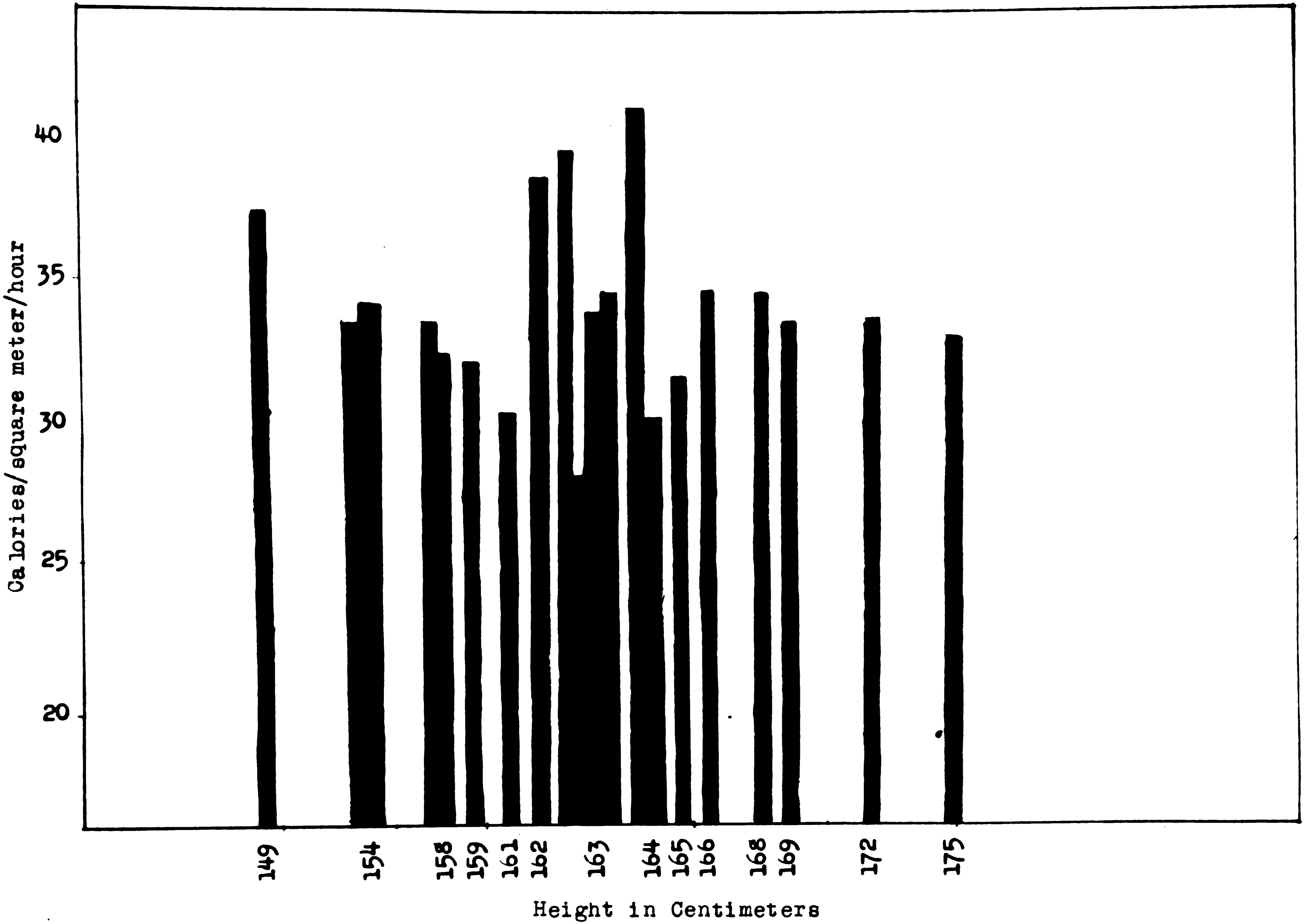
AGE - YEARS	AVE. OF ALL SUBJECTS CALS./KILO./24 HOURS	AVE. WITHOUT SUBJECTS 20% OVERWEIGHT
40-49	22.6	22.6
50-59	20.8	23.5
60-69	20.3	21.6
70-79	19.5	19.5

weight respectively. Five others are between 20% and 40% overweight. Omitting the averages of these overweight individuals we find the data in the third column of Table XXIII. The relationship of these averages by decades is similar to that of the averages compared on a surface area basis as presented in Table XXI.

The data are also presented in calories per centimeter per hour in Table XXII. An analysis of the data in relation to age does not seem to show a significant correlation. Dividing the subjects into the tall and short by setting 163 centimeters as the line of demarcation, it was found that the twelve women who were taller than 163 centimeters averaged 8.8 calories per centimeter per 24 hours. The average for the other women was 8.6 calories per centimeter per 24 hours. However an interesting fact is that the six tallest individuals, when compared on the basis of calories per square meter per hour, fall within a narrow range, which was nearly average for the entire group as may be seen in Graph II.

When basal metabolic rates are compared to blood pressure readings in Table XXII it may be seen that increased blood pressure accompanies higher basal metabolic rates. The average basal heat production of all the subjects is 34.1 calories per square meter per hour, but when Subjects X, XI, XII, XVI and XIX, who had systolic blood pressure readings over 200 m.m., were eliminated, the total average basal

Graph II.
BASAL METABOLIC RATES IN RELATION TO HEIGHT



heat production was reduced to 33.9. DuBois in his book "Basal Metabolism in Health and Disease" (p.395) states, "it is conceivable that the impaired circulation might change the oxygen demand of the tissues" and so affect the basal metabolic rate of individuals maintaining high blood pressure readings.

It may be seen in Table XXIV that the high pulse-rates do not appear to be correlated with an increase in age. Rather, pulse rate shows a definite relationship to the average calories per square meter per hour, as shown in Table XXIV. This table seems to indicate an increase in basal metabolic rate with an increase in pulse rate per minute. The fifteen subjects with pulse rates over 60 per minute, have an individual heat production between 31.1 and 41.2 calories per square meter per hour with an average heat production of 34.7 calories (Table XXIV). This is higher than the average for the five subjects whose pulse rates are below 60 (34.7 calories per square meter per hour). These results might be expected since DuBois, in his book "Basal Metabolism in Health and Disease", third edition, says, "it has long been known that the pulse-rate is roughly proportional to the level of the metabolism.". Harris and Benedict (1919) found in their series a "low but significant positive correlation between pulse rate and oxygen consumption . . . larger gaseous exchange being associated with more rapid pulse-rate.".

Table XXIV.

RELATION OF PULSE RATE TO

BASAL METABOLISM

PULSE RATE PER MINUTE	NO. OF SUBJECTS	AVERAGE OF SECOND AND THIRD DAY CAL./SQ.M./DAY
50-53	1	27.9
54-56	2	33.7
57-59	2	33.2
60-63	4	33.9
64-66	3	37.1
67-69	3	37.3
70-73	4	35.7
74-76	1	34.5

In Table XX it is shown that the total calories per day for the twenty women range from 1,100 to 1,700 calories inclusive. There seems to be little correlation between the total basal heat production and age. The last column in Table XX presents an estimation of the daily caloric intake of the subjects. The values were derived from one to four days' food records obtained on subjects as part of the larger study previously mentioned. These daily food intakes may not be entirely accurate estimates of food intakes of these individuals, but the figures probably represent the general food patterns of these women. Subjects II, XIII, XV and XVIII with a total heat production range of 1,100 to 1,200 calories per day have an estimated caloric intake of 1,770 calories. Subjects I, VIII, X, XI, XVII and XIX, with a range of 1,300 to 1,400 calories per day for basal heat production, have an estimated intake of 1,836 calories. Subjects III, VI, VII, IX and XX, whose basal heat production ranges between 1,500 and 1,600 calories per day, have an estimated food intake equal to 1,808 calories. Subject XII who had the highest basal heat production, equaling 1,700 calories per day, had a corresponding food intake of 1,942 calories. It is interesting to note, however, in appraising the individual basal heat production values and the daily colorie intake, that Subjects I and II con-

sumed 1,137 and 1,364 calories over their basal caloric needs respectively. Subjects VI, VIII, IX, X, XII, XIII, and XVIII had an estimated daily caloric intake of 497 calories over their basal heat production values. Subjects III, XVII and XX had an average of 59 calories per day over their basal needs. The remaining four subjects (Subjects VII, XI, XV and XIX) had an average estimated daily caloric intake of 87 calories under their total basal heat production.

SUMMARY AND CONCLUSIONS

The basal metabolic rates of twenty women between the ages of 48 and 77 years were observed. The averages of the second and third days' observations were used to report the data. The average calories per square meter per hour for the 40-49 year, 50-59 year, 60-69 year, 70-79 year age ranges were 32.6, 35.6, 33.7 and 31.9 respectively.

The average of the calories per square meter per hour in the 70-79 year age range was low (31.9 calories). There were only three women in this group and one had a very low basal metabolism. If the basal metabolism of the two women with the higher basal metabolism had been averaged, the resulting figure of 34.0 calories in this age range would not have differed much from the figure 33.7 calories of the 50-60 year decade.

In the age range 52-62 years, a relatively high average of 35.6 calories per square meter per hour was found. The question was raised whether or not this relatively high value might not be characteristic of the basal metabolic pattern of women in the period following the menopause.

The data of this study were also recorded in terms of calories per kilograms per 24 hours. These averages by decades showed slightly different relationship than the averages expressed in calories per square meter per hour. Deleting the eight women who were 20% overweight, the averages for calories per kilogram per 24 hours showed essentially the same relationship as the averages of calories per square meter per hour.

An analysis of high blood pressure and rapid pulse-rate showed no correlation with age, but a correlation was shown between pulse-rate and basal metabolism, as has been found in other age groups (Short and Johnson, 1936).

Comparison of subjects on the basis of height indicated no correlation between age and basal metabolism expressed in terms of calories per centimeter per 24 hours.

An appraisal of the relationship between basal calories of individuals and daily caloric intake seems to show a wide variation in the women of this series. The average basal heat production of calories per day for the entire series was equal to 1,429 calories per day while the average of the daily caloric intake equaled 1,839 or an average of 410 calories above the basal heat production. The values for caloric intake were derived from one to four days' food record as given by the subject. Two of the subjects had a

caloric intake that exceeded their basal needs by 1,100 calories. Seven of the subjects had caloric intakes that were 150 to 600 calories in excess of their basal heat production. Three subjects had caloric intakes from 35 to 71 calories over their basal needs. The remaining four subjects had caloric intakes from 49 to 138 calories less than their basal heat production.

No definite conclusions were drawn from the data of this study as the number of subjects was limited, however the degree of activity of these older women and its influence on the basal metabolism and the degree of aging seems an interesting and important problem. The possible rise in the basal metabolic rate of women in the age range 50 to 60 years, after the menopausal change has occurred, seems pertinent. Also the effect of this rise in basal metabolism on the caloric needs of women in this age range.

Further experimentation in basal metabolism of women in the higher decades, with particular attention to degree of aging and activity seems pertinent.

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