Overweight children usually become overweight adults, according to a study, spanning 20 years, of 200 residents of Hagerstown, Md.

Relationship of Excess Weight in Children and Adults

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THE ADVERSE effects of obesity upon health have been reported in life insurance and epidemiological studies (*1–4*). These reports have prompted investigators to employ various remedial methods and approaches to obesity (*5–9*).

The department of nutrition of the Harvard School of Public Health evaluated two approaches to weight control programs: individual counseling and group therapy (*10*). A 3-year followup showed that a majority of the 147 subjects failed either to reduce or to maintain a reduced weight. Stunkard and McLaren-Hume reviewed the literature of the past 30 years on results of treatment for obesity and found the results to be "remarkably poor" (*11*). Their own efforts with a group of outpatients were not successful in either reducing weight or maintaining a reduced weight for 2 years after treatment.

Young and others also reported the lack of success in a weight control program, but suggested the importance of childhood excess weight status as one of the factors determining adult excess weight status and of subsequent problems in weight control (*12*). They found that relative success was achieved in overcoming obesity when it was a recent development in the adult years. Mullin also reported, in a retrospective study, on the role of childhood obesity in adult obesity (*13*). He suggested that a persistent childhood obesity is reflected in a large proportion of adult obesity.

Height-weight data on school children examined some 20 years ago in Hagerstown, Washington County, Md., by the U.S. Public Health Service, presented an opportunity for a prospective study of the relationship of the weight status of individuals in childhood and adult years. Previous observations suggesting a relationship between childhood and adult obesity have been based primarily on retrospective studies of obese adults who have been interviewed about the history of their weight status. Childhood heights and weights on record in the Hagerstown sample supplied data that did not rely on memory for testing the hypothesis that obese children tend to become obese adults.

Method

Physical examinations of school children in three elementary schools in Hagerstown were performed during the years 1937–39. These

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records, containing height-weight data, are on file in the Public Health Service office in Hagerstown (*14*). Physical measurement data are available on 977 of the 1,204 boys and 966 of the 1,152 girls examined at ages 10 through 13 years. Cohorts were selected on the basis of available serial height-weight data.

The examiners measured heights without shoes. At the weighing, the children removed shoes, sweaters, or coats, but retained usual indoor clothing.

Table 1. Distribution of relative weight of school children 10–13 years of age in 3 schools in Hagerstown, Md., 1937–39

Relative weight	Boys		Girls	
	Number	Percent	Number	Percent
Total	977	100.0	966	100.0
60–69	0	0	1	0.1
70–79	4	.4	18	1.9
80–89	120	12.3	207	21.4
90–99	455	46.6	387	40.1
100–109	279	28.6	202	20.9
110–119	80	8.2	81	8.4
120–129	14	1.4	29	3.0
130–139	16	1.6	21	2.2
140–149	5	.5	9	.9
150 and over	4	.4	11	1.1

The weight status of each child was determined by using a relative weight method, defined as the percentage deviation of actual weight from the average weight for a given sex, age, and height. Average weights were obtained from the Baldwin-Wood height-weight tables (*15*). The distribution of these relative weights is shown in table 1.

Studies of the relationship of obesity to health and disease usually measure obesity in terms of departure of actual weight from a height-weight standard. Obesity or an excess accumulation of fat, therefore, is used interchangeably with overweight or excess weight above standard weight. The limitations of using height-weight tables in this study to determine true obesity were recognized (*16*). Total body weight is a measure of bone, muscle, and fat, and departure from average weight may be due to one or another or a combination of these body components. Overweight prevention and control is directed against overweight due to excess fat, primarily attributed to excess food intake over the energy demands of the individual; therefore an effort was made to identify the obese children in the overweight group.

For purposes of weight classification, children were placed in categories of average weight and overweight, and the population was arrayed from largest to smallest by relative weight. Fifty children or approximately 5 percent of the upper distribution of relative weight were chosen for each sex as overweight. The relative weight values of boys ranged from 180 to 116; for girls, from 200 to 124.

This selection of overweight subjects who have extreme relative weight values increases the likelihood that truly obese subjects have been chosen (*17*). The validity of relative weight measures as an indication of obesity is discussed in the statistical notes.

These findings indicate that, on the average, overweight children are fatter by measurement as well as weight than average weight children.

One hundred children were also selected for the "average weight" classification. Since the distribution of relative weight was skewed toward the higher values, average weight was computed by the median. Relative weights were 98 for boys and 97 for girls. Arbitrarily, we decided to use plus or minus five about 100. Therefore, average weights for the purpose of this study are the relative weight values from 95 through 104. In these categories, there were 425 boys and 290 girls. To select 50 children of each sex for this study, a 12 percent and 17 percent random sample of boys and girls in this weight category were taken.

Table 2 identifies relative weights of the study subjects in each weight classification with regard to the relative weights of the total school population.

Adult Followup

The adult followup was made in the summer of 1958 (table 3). Of the 200 children whose records were selected for the study, 174 or 87 percent were located. However, only 120 were used in this study since 47 were eliminated because of nonresidence in Washington County

Table 2. Distribution of relative weight of school population and of study group, 10–13 years of age, by major weight category, Hagerstown, Md., 1937–39

Relative weight	Boys		Girls	
	School population	Study group	School population	Study group
Total	977	100	966	100
Below average (less than 95)	320	0	435	0
Average (95–104)	425	50	290	50
Overweight, total	232	50	241	50
105–119	193	13	171	0
120–129	[1] 14	13	29	12
130–139	16	16	[1] 21	20
140–149	5	5	[2] 9	7
150 and over	[1] 4	3	11	11

[1] 1 in this weight category not sought due to inadequate records.
[2] 2 in this weight category not sought due to inadequate records.

and 7 because they were not available for interviewing.

Each interviewer carried a measuring stick and a portable scale for height and weight measures. Weight status was measured in terms of relative weight, computed as the percentage deviation of actual weight from average weight for a given height, age, and sex. Average weights were obtained from height-weight tables in the Medico-Actuarial mortality investigations of 1912 (*18*) and distributed by the Metropolitan Life Insurance Company. (Revised tables of average weights were a part of the "1959 Build and Blood Pressure Study," recently published by the Society of Actuaries (see p. 266). Publication followed preparation of this paper. An analysis, using these more recent figures, revealed no noteworthy change in the results obtained.)

Distribution for relative weights of adults was not available, but 20 percent or more above average weight was defined as marked overweight (*1*). Average weight was calculated in a manner similar to that for children whose relative weight values ranged from 95 through 104.

Average age of adults was 31 years. For men, ages ranged from 27 to 36 years, for women, from 26 to 35 years.

Of the 28 interviews with average weight men, 26 were used in the study and 2 for pretesting. One interview with an average weight woman was used for pretesting; all other interviews, a total of 29, were used in the study.

Interviews with 32 overweight men were used in the study and 2 were used for pretesting. Twenty-seven interviews with overweight women were used in the study and one was used in pretesting.

No bias was introduced by attrition since childhood weight status of those who were not interviewed did not differ from those who were. The statistical notes analyze the differences

Table 3. Result of followup of study group, by childhood weight status

Results	Total population		Men				Women			
			Average		Overweight		Average		Overweight	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Total	200	100	50	100	50	100	50	100	50	100
Located	174	87	45	90	42	84	41	82	46	92
Interviewed	120	60	28	56	34	68	30	60	28	56
Located but not interviewed	54	27	17	34	8	16	11	22	18	36
Out of county	*47*	-------	*13*	-------	*7*	-------	*10*	-------	*17*	-------
Not available for interview	*7*	-------	*4*	-------	*1*	-------	*1*	-------	*1*	-------
Cannot locate	23	-------	4	-------	6	-------	9	-------	4	-------
Died	3	-------	1	-------	2	-------	0	-------	0	-------

Revised Tables of Average Heights and Weights

In October 1959, the Society of Actuaries published the results of the largest statistical investigation ever attempted in the field of public health, entitled "1959 Build and Blood Pressure Study." The data cover the 20-year experience of 26 large life insurance companies. Five million policyholders are represented in the revised tables of average heights (with shoes) and weights given below.

AVERAGE WEIGHTS OF MEN

Graduated Weights (in indoor clothing) in Pounds

Height	Age Groups 15-16	17-19	20-24	25-29	30-39	40-49	50-59	60-69
5′ 0″	98	113	122	128	131	134	136	133
1″	102	116	125	131	134	137	139	136
2″	107	119	128	134	137	140	142	139
3″	112	123	132	138	141	144	145	142
4″	117	127	136	141	145	148	149	146
5″	122	131	139	144	149	152	153	150
6″	127	135	142	148	153	156	157	154
7″	132	139	145	151	157	161	162	159
8″	137	143	149	155	161	165	166	163
9″	142	147	153	159	165	169	170	168
10″	146	151	157	163	170	174	175	173
11″	150	155	161	167	174	178	180	178
6′ 0″	154	160	166	172	179	183	185	183
1″	159	164	170	177	183	187	189	188
2″	164	168	174	182	188	192	194	193
3″	169	172	178	186	193	197	199	198
4″	*	176	181	190	199	203	205	204

AVERAGE WEIGHTS OF WOMEN

Graduated Weights (in indoor clothing) in Pounds

Height	Age Groups 15-16	17-19	20-24	25-29	30-39	40-49	50-59	60-69
4′ 10″	97	99	102	107	115	122	125	127
11″	100	102	105	110	117	124	127	129
5′ 0″	103	105	108	113	120	127	130	131
1″	107	109	112	116	123	130	133	134
2″	111	113	115	119	126	133	136	137
3″	114	116	118	122	129	136	140	141
4″	117	120	121	125	132	140	144	145
5″	121	124	125	129	135	143	148	149
6″	125	127	129	133	139	147	152	153
7″	128	130	132	136	142	151	156	157
8″	132	134	136	140	146	155	160	161
9″	136	138	140	144	150	159	164	165
10″	*	142	144	148	154	164	169	*
11″	*	147	149	153	159	169	174	*
6′ 0″	*	152	154	158	164	174	180	*

* Average weights omitted in classes having too few cases.

between weight status of subjects who were not interviewed and those who were.

Replacements

Subjects who were lost from the initial study group were replaced in order to maintain the original number of 50 males and 50 females in each of the sex and weight categories. Random selections were made from the reservoir of average weight persons so classified originally in the school population. Replacements for the overweight males and females were obtained by selecting the next most overweight from the distribution of relative weight below the upper fifth percentile. By this method, of course, less grossly overweight persons as originally defined were included in the final overweight group. For boys, the relative weights of replacements ranged from 116 to 108, for girls, from 124 to 110. Because relative weights as low as 108 for boys and 110 for girls were included, it was decided to identify two classifications of overweight: moderately overweight, relative weights of 105 through 119, and markedly overweight, relative weight of 120 and more.

Results

Figures 1 and 2 illustrate the trend in weight status from childhood to adulthood of average weight and overweight children. These trends are summarized in tables 4 and 5, which show the comparison between childhood and adult weight status for males and females. For each sex, it is apparent that overweight children tend to become overweight adults more often than children of average weight. Of the 50 overweight boys, 43, or 86 percent, were overweight as adults. Of the 50 average boys, 21, or 42 percent, were overweight as adults. Approximately twice as many overweight boys were overweight adults in comparison to average weight boys. More striking differences in adult overweight status are noted in comparing overweight girls and average weight girls. Of the 50 overweight girls, 40, or 80 percent, were overweight as adults; only 9, or 18 percent, of the 50 average girls were overweight as adults. In both comparisons, the differences are statistically significant: for boys, chi-square=19.14, D.F.=1, $P<.001$; for girls, chi-square=36.01, D.F.=1, $P<.001$.

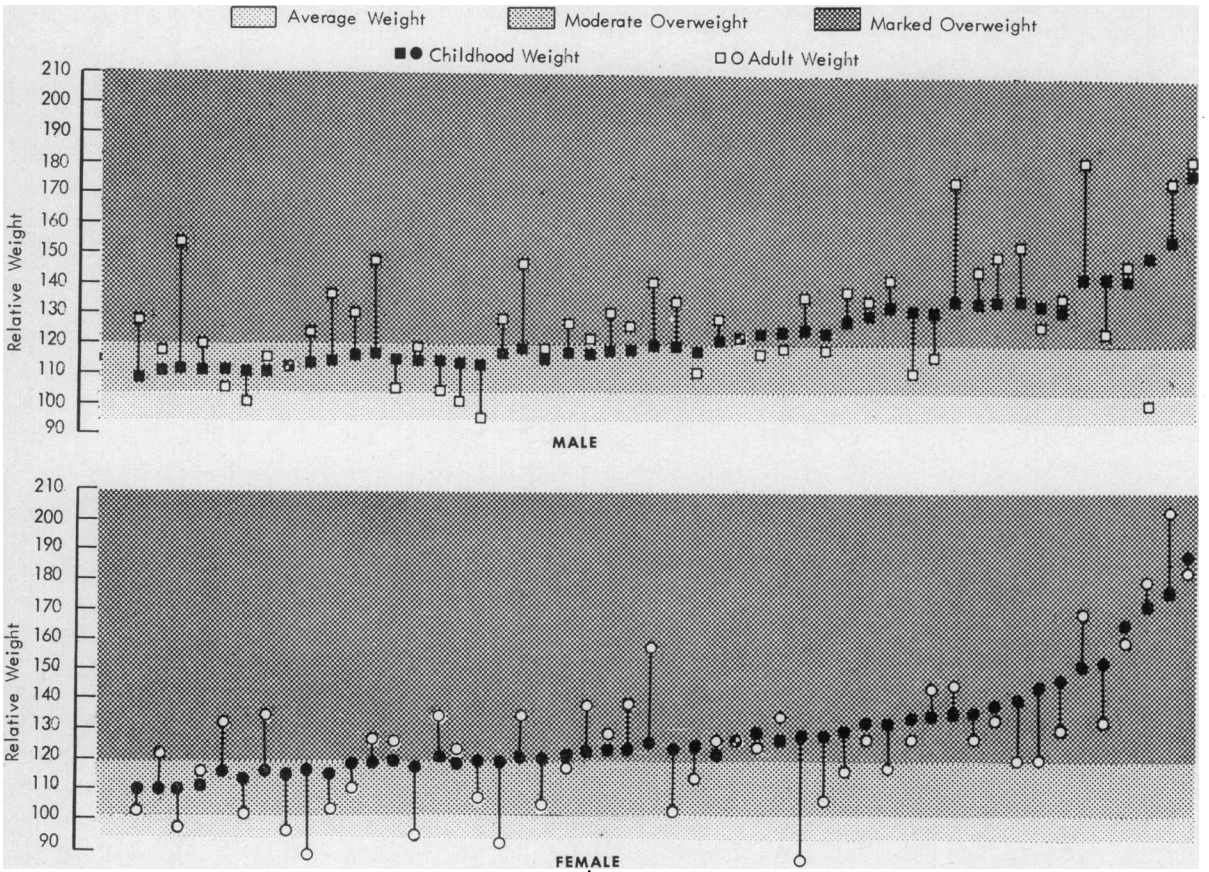
It is also apparent from these data that markedly overweight girls and boys are more likely to become overweight adults than the moderately overweight. Seven, or 50 percent, of the moderately overweight girls were average or less than average weight as adults. This observation contrasts with 3, or 8 percent, of the 36 markedly overweight girls who were average or less than average weight as adults. The same findings, but with less difference in percentage, are noted when a comparison is made of moderately overweight and markedly overweight boys; the percentages observed are 22 percent and 4 percent, respectively. These observations reflect the loss of girls and boys in overweight categories who were selected from the upper part of the distributions of relative weight. The data suggest that if, as originally planned, only those in the upper 5 percent of the distribution had been used, more of the overweight children would have fallen into adult overweight categories.

It is quite likely that some persons are in their present weight status because of efforts toward weight reduction or because of the effect of a disability or disease. Some information was gained by asking each person about his usual weight in contrast to his present weight, with the specification that the answer apply to a period at least 6 months prior to the date of interviewing. The results indicated no significant difference in mean relative weights for males and females for the two periods of time.

Discussion

Interest in overweight stems in great part from the role which this factor may play in the etiology of disease, particularly cardiovascular disease. The bulk of the data on weight control lies in the statistics in life insurance studies (*1*) which have shown repeatedly a significantly higher mortality rate for overweight persons than for persons of average and less than average weight. These findings have been supported also by data from the Framingham heart study conducted by the National Heart Institute of the Public Health Service. In the fourth year of followup of men aged 45–62 years, it was found that overweight was clearly associated with the risk of development

Figure 1. Adult weight status of average weight children of both sexes, 10 to 13 years of age, Hagerstown, Md., 1937–39



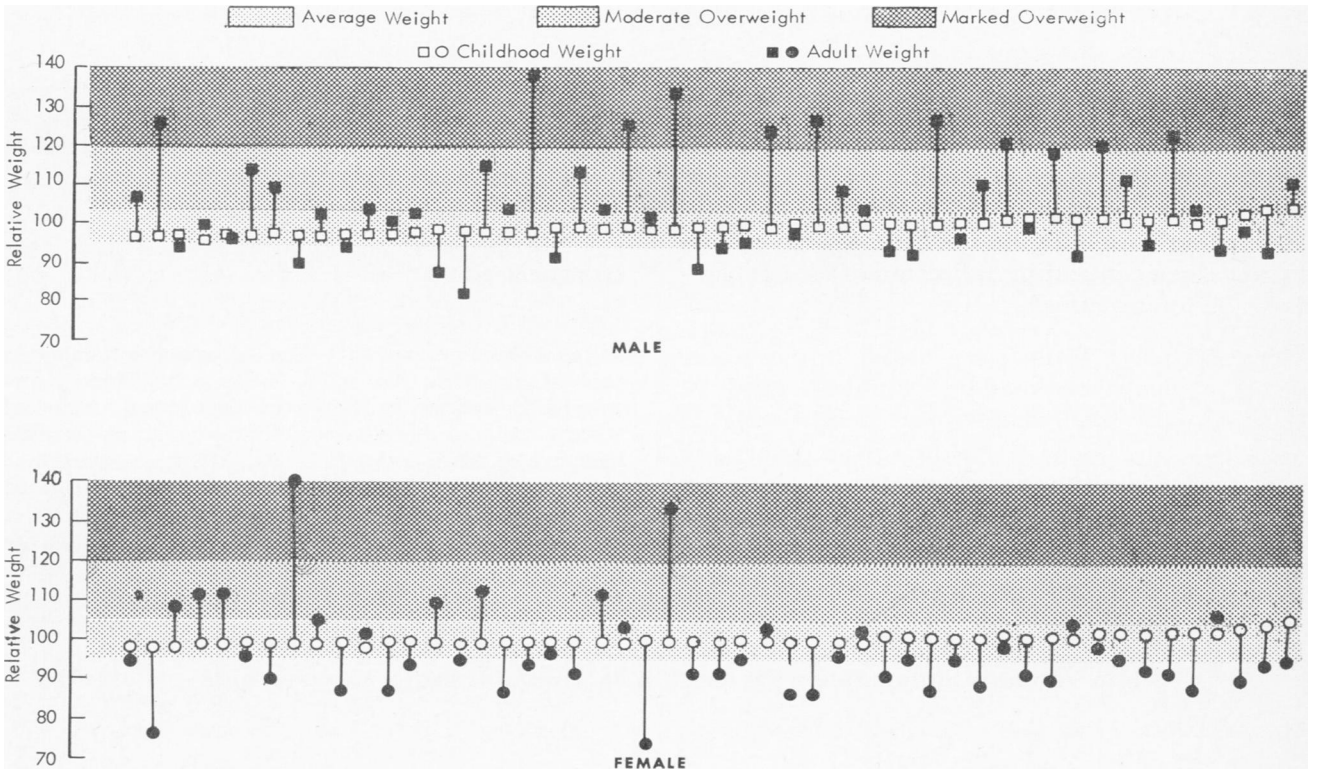
of coronary heart disease (*2*). Coronary heart disease incidence rates of overweight men were three times as great as those for men whose weight was below the median weight.

It has been assumed that if diseases, particularly cardiovascular diseases, are induced or adversely influenced by overweight, weight reduction would tend to decrease morbidity and

Table 4. Weight status by major category of selected male residents of Hagerstown, Md., as school children and as adults

Childhood weight	Selected male residents		Adult weight					
			Less than average and average weight (less than 105)		Moderately overweight (105–119)		Markedly overweight (120 and more)	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Average weight (95–104)	50	100. 0	29	58. 0	11	22. 0	10	20. 0
Overweight, total	50	100. 0	7	14. 0	12	24. 0	31	62. 0
105–119	27	100. 0	6	22. 2	7	25. 9	14	51. 9
120 and more	23	100. 0	1	4. 3	5	21. 7	17	73. 9

Figure 2. Adult weight status of overweight children of both sexes, 10 to 13 years of age, Hagerstown, Md., 1937–39



mortality from such diseases. The effect of weight control on the mortality experience of insured persons has also been reported by life insurance studies (*19*). These studies have added impetus to weight control as a preventive measure against cardiovascular heart disease. It was found that weight reduction improved the health outlook for those persons who had lost enough weight to qualify for a new insurance rating. As an example, men originally limited to substandard insurance because they were moderately overweight, upon weight reduction had a lessened mortality rate of 113 percent of the standard, compared with

Table 5. Weight status by major category of selected female residents of Hagerstown, Md., as school children and as adults

Childhood weight	Selected female residents		Adult weight					
			Less than average and average weight (less than 105)		Moderately overweight (105–119)		Markedly overweight (120 and more)	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Average weight (95–104)	50	100. 0	41	82. 0	7	14. 0	2	4. 0
Overweight, total	50	100. 0	10	20. 0	9	18. 0	31	62. 0
105–119	14	100. 0	7	50. 0	2	14. 3	5	35. 7
120 and more	36	100. 0	3	8. 3	7	19. 4	26	72. 2

the mortality rate of 142 percent for all moderately overweight males.

It has been found from studies and reports from clinics for weight control that guided efforts toward their goals are ineffective and impermanent. It would appear that early onset of overweight is an important factor to consider when persons apply for treatment. Education and therapy should be directed toward weight control in the early stages of life. According to Young and others, overweight is "probably a continuing reflection of other childhood characteristics" (*12*).

Summary

A followup was made of children aged 10 through 13 years whose serial height-weights were recorded some 20 years ago to determine their present adult weight status.

It was observed that overweight children tend to become overweight adults more often than children of average weight.

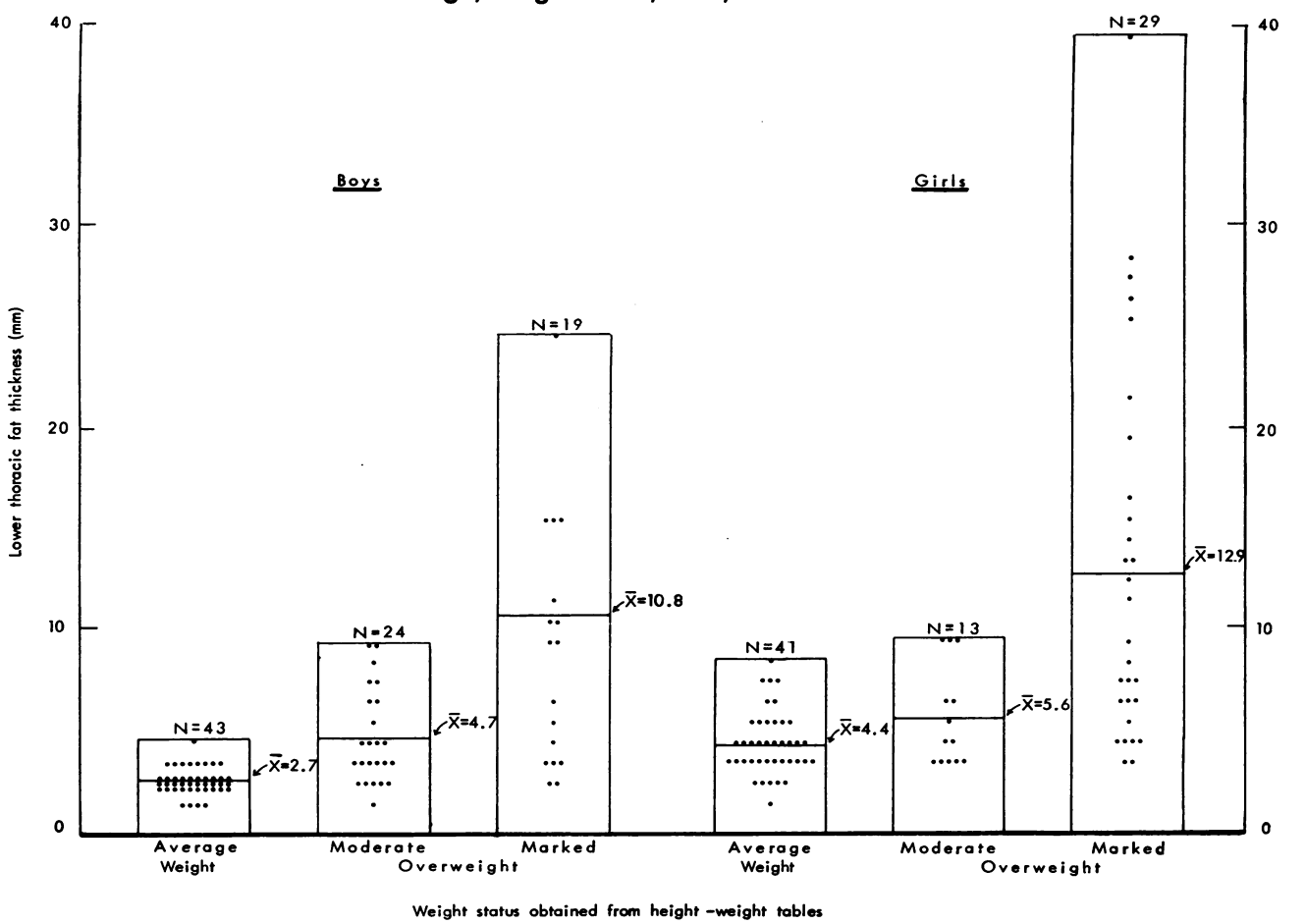
The difficulty that obese adults experience in weight control may be rooted in the fact that overweight children tend to become overweight adults. It may, therefore, be reasonable to suggest that part of the failure of traditional weight control activities is due to overemphasis on adult eating patterns.

STATISTICAL NOTES

Validation of Relative Weight Measures

The term "overweight" is used interchangeably in this study with the term "obesity." Since overweight is defined in terms of departure of actual weight from a height-weight standard, no specific measure of fat is available. An effort was therefore made to validate the overweight measure, expressed

Figure 3. Distribution of fat thickness in weight categories, by sex, of children 10 to 13 years of age, Hagerstown, Md., 1937–39



in terms of relative weight, with the measure of obesity. Chest X-rays were available on 86 boys and 83 girls in the study group. They were read for measurement of fat at the Fels Research Institute, Yellow Springs, Ohio, by Miss Joan A. Haskell. Measurements of fat in the lower thoracic region were taken at the level of the 10th rib on both right and left sides, perpendicular to the fat shadows (*20*). When X-rays of this particular site were faulty due to improper positioning or extension of the chest beyond the plate, fat measurements were taken at the ninth rib. In a few cases, the X-rays were completely unreadable at both the 9th and 10th rib site, and no measurement of fat thickness was attempted. This was unfortunate since these measurements represented some of the more obese subjects. A complete series of measures was made on two different occasions. Since reproducibility was high, a mean value of fat per individual was calculated.

One approach in evaluating the relationship between overweight and obesity is illustrated in figure 3. This shows the distribution of fat thickness in the lower thoracic region of designated weight categories for boys and girls. It is apparent that the distribution of fat thickness overlaps the weight categories.

Some average weight children had fat measures equal to those of moderately and markedly overweight children. There were also some with larger fat measures. This occurred more frequently in girls than boys.

The difference in means of fat thickness, as indicated in figure 3 and table 6, shows an increase in mean fat thickness with the increase in weight status. For boys, the fat thickness was four times as great for the markedly overweight as for the average weight (10.8 mm. vs. 2.7 mm.). The comparison was approximately three times as great for girls (12.9 mm. vs. 4.4 mm.).

Comparison of the means of weight categories was made by the test of the significance using the F distribution in the analysis of variance after the fat distributions were normalized using McCall's technique, cited by Garn (*21*). The transformation to normalized T-score tended to normalize the fat distribution and provided equal variances. The F test showed a significant difference in means: Boys $F_{.01}$ (2,83) =4.9, F=36.8; girls, $F_{.01}$ (2,80) =4.9, F=20.7.

F tests permit an analysis which rejects the null hypothesis that all of the means are equal, but they do not provide a procedure for comparing specific means with one another. Multiple compari-

Table 6. Measurement of fat thickness of children by major weight category and by sex

Weight group	Boys				Girls			
	Number	Fat thickness (mm.)			Number	Fat thickness (mm.)		
		Mean	Standard deviation	Range		Mean	Standard deviation	Range
Average weight	43	2. 7	0. 56	1. 7–4. 3	41	4. 4	1. 6	1. 8–8. 4
Overweight:								
Moderately	24	4. 7	2. 3	1. 5–9. 5	13	5. 6	2. 5	3. 2–9. 8
Markedly	19	10. 8	6. 4	2. 9–24. 3	29	12. 9	9. 3	3. 3–39. 1

Table 7. Comparison of fat thickness in weight categories of children 10–13 years of age, Hagerstown, Md., 1937–39

Comparison	Confidence limits[1]	
	Male	Female
Average weight-overweight	13. 8±3. 8	8. 7±4. 3
Average weight-markedly overweight	−17. 1±4. 8	−13. 0±4. 8
Moderately overweight-markedly overweight	−6. 5±5. 4	−8. 6±6. 6
Average weight and moderately overweight-markedly overweight	−11. 9±4. 6	−10. 8±4. 6

[1] There is evidence, using the q statistic at the 5 percent level to reject the zero value for all the comparisons made, using the following formula: $\overline{X}_1-\overline{X}_2\pm\frac{\text{Student range}}{\sqrt{2}}\sqrt{\text{Mean square for error}\left(\frac{1}{n_1}+\frac{1}{n_2}\right)}$

son tests provide this method (*22*). Table 7 shows the statistical evaluation of these comparisons.

It is evident that there is a significant difference in fat thickness between average weight and overweight children, between a combination of average and moderately overweight with markedly overweight, between moderately and markedly overweight, and between average and markedly overweight children. These findings indicate that the markedly overweight children had, on the average, a larger measure of fat thickness than those selected from the remainder of the designated area

Table 8. Initial selections and replacements for study of male residents of Hagerstown, Md., by childhood weight status in major weight categories

Childhood weight status	Initial group			Final group		
	Number in group	Number available	Number not available	Number in group	Number available	Number not available
Average weight						
Total	50	28	22	50	26	24
95–96	2	[1] 1	1	4	0	4
97–98	12	7	5	14	7	7
99–100	20	[1] 13	7	18	12	6
101–102	10	6	4	11	6	5
103–104	6	1	5	3	1	2
Overweight						
Total	50	34	16	50	32	18
105–119	13	[1] 10	3	27	9	18
120–129	13	7	6	7	7	0
130–139	16	[1] 11	5	10	10	0
140–149	5	3	2	3	3	0
150 and over	3	3	0	3	3	0

[1] Interviewed but not included in the final study group because used for presurvey testing.

Table 9. Initial selections and replacements for study of female residents of Hagerstown, Md., by childhood weight status in major weight categories

Childhood weight status	Initial group			Final group		
	Number in group	Number available	Number not available	Number in group	Number available	Number not available
Average weight						
Total	50	30	20	50	29	21
95–96	3	1	2	1	1	0
97–98	10	7	3	18	7	11
99–100	27	17	10	21	17	4
101–102	8	[1] 4	4	7	3	4
103–104	2	1	1	3	1	2
Overweight						
Total	50	28	22	50	27	23
105–119	0	0	0	14	0	14
120–129	12	8	4	17	8	9
130–139	20	[1] 10	10	9	9	0
140–149	7	4	3	4	4	0
150 and over	11	6	5	6	6	0

[1] Interviewed but not included in final study group because used for presurvey testing.

of the distribution of relative weight. However, it should be stated that, on an individual basis, some of the overweight children, particularly the moderately overweight, could be classified as overweight not due to fat but due to frame or muscular development.

Bias From Followup Attrition

Locating and interviewing children originally examined in 1937–39 for a prospective study raised the question of how many of the selected study group could be found in 1958. Losses might introduce a bias as the weight status of the average and overweight individuals located and interviewed might not be representative of the average and overweight categories as initially selected. Tables 8 and 9 show the number of average weight and overweight males and females who were either available for interview or not available for interview in the original study selection, and the replacements made for those who were not available.

Bias is minimized in the average weight group because of the method used in selecting individuals for this category. The range of weights was plus or minus 5 percent about the relative weight of 100. This narrow range tended to decrease the difference between the weight status of those individals interviewed and those individuals not interviewed. The difference between means was statistically not significant. For males of average weight, the mean relative weight of individuals not interviewed was 100.0 and of subjects was 99.7 ($.2>P>.1$). For females of average weight, the contrast in mean relative weights was 99.9 as compared to 99.8 ($P>.9$).

The problem of attrition is more pertinent in the overweight than in the average weight category, since the range of relative weight selected from the distribution of relative weights of the total population varied from the relative weight of 180 to 116 for males and from 200 to 124 for females. The hypothesis that there is no significant difference between the distribution of relative weight of those persons who were interviewed and those who were not interviewed was tested by using the chi-square statistic. This test indicated that the difference between the groups could have arisen by chance ($.7>P>.5$) and ($.8>P>.7$).

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