Relative Importance of Inactivity and Overeating in the Energy Balance of Obese High School Girls

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The fact that a substantial, and perhaps increasing, proportion of United States children are obese, together with current emphasis on the problem of weight control, has focused attention on the possible causes of this condition. Interest has been heightened by the recognition that obesity in children and adolescents, particularly if it has been persistent throughout a major portion of the growth period, is of a particularly “resistant” character.1,2,3

Attempts at explanation have been explicitly based on the concept that the excess calories accumulated as fat must reflect an abnormally large caloric intake. The other possibility leading to a surplus of calories available for fat synthesis, namely reduced caloric output, was not usually considered because of the generally current misunderstanding of the relation of exercise to food intake and weight. This misunderstanding is based on two fallacies, (1) that exercise consumes relatively little energy, and (2) that appetite is enlarged automatically when exercise is increased from any level.4 The considerable cost of exercise, symbolized by the wide spread of caloric allowances depending on activity level, is dis cussed in the recommendations of the League of Nations and by the Food and Nutrition Board of the National Research Council.

It has also been shown that in experimental animals5 and in adult men3 there exists a “sedentary range” in which short periods of activity are not followed by increases in daily intake. Total absence of such activity leads to accumulation of weight4 and even obesity in animals5,6 and in man3,7 In at least one form of experimental genetic obesity, decreased activity is responsible for the greater part of the caloric surplus accumulated as fat.8 Such facts suggest that inactivity also could be a major factor in the etiology of obesity in children and adolescents.

Bruch9 found inactivity characteristic of the majority of a group of 100 obese children. She felt that 76 per cent of the boys and 68 per cent of the girls were abnormally inactive; only 18 per cent of the boys and 22 per cent of the girls fell within the normal range of activity. Rony,10 Bronstein and associates,11 and Graham12 have reported similar findings. More recently Tolstrup13 and Juel-Nielsen11 have emphasized the widespread inactivity of

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obese children. Peckos found that there was no correlation between the body build, its fat content and distribution, and caloric intake. Fry, studying obese children, selected on the basis of fat pads, found that these children did not have a higher average caloric intake than did comparable nonobese children. In her tabulation, a much higher proportion of obese than nonobese children were labeled as only moderately active or as inactive. This difference appeared particularly marked among the boys. No data were given to support these statements, so it becomes difficult to evaluate the contribution of inactivity to caloric excess for these children.

The study presented here is a comparison of both caloric intake and activity in paired groups of obese and nonobese high school girls. Research dietary histories and activity schedules covering the year preceding the study were obtained. Results indicate that for the groups considered, the caloric intake of the obese children was not higher and in most cases was lower than that of their nonobese controls; the marked inactivity of the obese group accounted for the caloric surplus in these adolescents.

DESCRIPTION OF THE SAMPLE

Two matched groups of 28 obese girls and 28 nonobese girls were selected from three upper grades of a high school in one of the suburbs of Boston. Each girl's participation in the study was on a voluntary basis. The obese girls were selected on the basis of maintaining for one year the physique status of A4 or heavier according to a modified Wetzel Grid which had been provided with additional extreme channels. The "physique channels" were extended beyond channel A4 to "channel A12" by drawing equidistant lines parallel to the channels on the original Grid. This overcame in a measure the difficulty mentioned by Bruch that older and more obese children fall outside the range which could be evaluated by the Grid. In terms of evolution of height and weight with age, selection was made so that the obese group, in so far as possible, represented individuals in each channel, A1 and above. In terms of absolute weight, the obese group, according to the Baldwin-Wood tables, ranged from 13 to 68 per cent above the average for their age, height, and sex, with a mean of 31.6 per cent above the average. For each obese girl, a nonobese control was selected on the basis of similarity of chronological age, height, and school grade. The control girls were in Wetzel Grid channels A1, M, or B1 at the time of their most recent physical examination. These girls ranged from 16 per cent below to 2 per cent above the average weight for their age, height, and sex according to the Baldwin-Wood tables. The mean for the control group was 7.8 per cent below the average weight. Seventy-one per cent of the obese girls and 59 per cent of the control girls had gained weight during the previous year.

METHOD

The girls were interviewed individually. The Burke Research Dietary History Method was used for collecting dietary information. The caloric and protein content of the diets were calculated from a composite table of representative food values used in previous studies by the Department of Maternal and Child Health, Harvard School of Public Health.

A picture of the physical activity, as exhaustive as possible, was obtained by an interview procedure conducted in the following manner. A list of usual activities was established and the subjects were asked how much time they devoted to each, daily or weekly. The list of activities and the schedule were rechecked carefully by each subject. An effort was made to cover the whole school year, making proper allowances for seasonal differences. Schedules for weekdays and week ends were differentiated. The total number of hours was then added and averaged on a weekly basis so as to compare this total with the actual number of hours in a week. In the questioning and cross-questioning, broad classes of activity were considered separately and an effort made to in-

* The authors are aware that the Baldwin-Wood figures are based upon measurements of height and weight of a previous generation somewhat smaller than the present generation. However, these standards suffice to illustrate the relative obesity of these girls in relation to their controls.
dividualize types within each class. The activities were summarized and the totals and averages rechecked with the subjects in another interview. If the total time per week had been grossly overestimated or underestimated, special efforts were made to find sources of error. If there was doubt concerning time spent in various activities, the subject was asked to describe in detail her daily schedule. This was done to give a better perspective of time distribution within a 24-hour period rather than to describe a 'representative day.'

Activities were classified into broad groups according to ratings of energy expenditure. These ratings were based on estimations of caloric expenditure above basal as compiled by Rose.21 For activities not included by Rose, factors were calculated in a similar fashion from figures given by Orr and Leitch.22 For those for which no energy measurement could be found, a factor corresponding to that of an activity judged to be similar in intensity was used. The caloric factor was multiplied by total hours per week spent in each activity. The products were totaled and divided by seven to find the "activity index" per day.

Other pertinent information collected from each girl included menarcheal age, number of brothers and sisters, and height and weight of parents.

**RESULTS**

*Characteristics of the Groups Studied*

While the two groups were selected with the hope that the only variable would be weight, having been matched in age, school class, and in height in so far as possible,* other characteristics were found to differ. Only 7 obese girls had grown as much as one-half inch in the preceding 12 months, the others a quarter inch or less. By contrast, the control girls in general were still growing. During the year preceding this study 18 had grown between one-half and one and one-half inches and only 9 had grown one-quarter inch or less.

The obese girls showed a tendency to earlier maturation than the control girls as judged by menarcheal age. Menarche occurred before 12 years of age in 8 of the obese group but in only 3 of the controls. When the menarcheal age of each obese girl was compared with that of her control, it was found that in 17 of the obese girls menarche occurred earlier, in 8 later, and in 3 at the same age. Although in as small a sample as this one, the difference in age of menarche was not statistically significant, the data suggest earlier maturation in the obese girls.

There was no significant difference between the obese and control groups in the number of girls who were an only child, the youngest child, or the oldest child in their respective families as postulated by Bruch19. In contrast to earlier observations,24,35,13,18 the obese girls in this sample did not have fewer siblings than the girls in the control group.

The average weight of the parents was above "ideal" weight as defined by the Metropolitan Life Insurance Company.26,27 Among the parents of the obese girls, 33 per cent of the fathers and 42 per cent of the mothers were 20 per cent or more above "ideal" weight; in contrast, only 21 per cent of the fathers and 7 per cent of the mothers of the control girls were in these categories. The difference in prevalence of obesity among mothers of obese girls and mothers of control girls was highly significant. The corresponding difference for fathers was not significant.

Two of the obese girls had been delayed one year in school grade, 26 had progressed normally. The nonobese girls had all progressed normally.

* Selection of control group:

For each obese subject a control subject meeting the following specifications was selected:

1. Within ± 6 months (except in one case, 8 months) of the age of the obese girl.
2. Within ± 1 inch of the height of the obese girl at the 1953 physical examination.
3. In the same school class (one exception, when the obese subject had been retained in one grade for 2 years).
4. In Wetzel Grid physique channels A, M, or B, "Good" according to Wetzel.

First girl in the medical record file, which is arranged alphabetically by class, following the obese girl and who met all of the above specifications was selected as the control.
Dietary Information

Table I gives the daily average caloric intake of the obese and nonobese group. It is readily seen that the caloric intake of the obese girls is significantly lower than that of their controls.

<table>
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<tr>
<th>TABLE I</th>
<th>Average Daily Caloric Intake of Obese Girls and of Control Girls, by Class and By Age</th>
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<tr>
<td>Group</td>
<td>Number</td>
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<td></td>
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<tr>
<td>Obese</td>
<td>28</td>
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<td>Controls</td>
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This is also true for each class and age group. Only 9 of the obese girls reported intakes above 2000 calories per day as compared with 25 of their controls. A wide range of daily caloric intakes was reported for both groups, i.e., in the obese group the range was 1405 to 3114 calories and in the control group from 1688 to 4171 calories. No consistent increase or decrease of mean daily caloric intake was seen with increase of mean age from Sophomore through Senior class. Eighty per cent of the caloric intakes of the obese and 40 to 50 per cent of those of the nonobese in each age group were below the Recommended Dietary Allowances of the Food and Nutrition Board of the National Research Council.

A lower mean protein intake accompanied the lower caloric intake of the obese group as compared with that of the control group. The range of daily protein intakes was wide for both the obese girls (46 to 107 grams) and the control girls (68 to 150 grams). There was no significant difference between the obese and control groups in percentage of total calories derived from protein: 10 to 21 per cent for the obese group; 11 to 18 per cent for the control group. Beaudoin and Mayer found no significant difference in percentage distribution of calories from protein, fat, and carbohydrate in the diets of the obese and nonobese women whom they studied.

Both the obese girls and their nonobese controls had snacks in the afternoon and at bedtime. More of the control girls had snacks in the afternoon, but the difference was not significant. An almost equal number in each group had bedtime snacks. No particular tendency for heavier food intake in the evening as reported by Beaudoin and Mayer and Dole and co-workers was observed in either group. The number of girls who skipped breakfast entirely at least twice a week was higher, though not significantly so, in the obese group, 8 compared with 3 of the control group.

Activity Information

Both the obese girls and their controls might be considered "sedentary," since 90 per cent and 85 per cent of their time, respectively, was spent in a combination of sleeping, lying still, or sitting. Similar amounts of time were spent by the two groups in such activities as baby sitting, playing the piano, driving a car, and "housework" (Table II). "Active sports and other strenuous activities" accounted for the greatest difference in level of activity and was significantly less in the obese group than in their controls. Of the few obese girls who were very active, most were quite proficient in their favorite activity. This was particularly true of skating and swimming.

The obese girls had significantly lower activity indices than the control girls (Table III). In only six cases was the activity index of the
obese girl equal to or greater than that of her control.

No consistent difference in attitudes of parents toward strenuous physical activity for their daughters was observed between the obese and control groups, as previously reported by Bruch. Several of the girls in both groups volunteered the information that participation in competitive outdoor activities had been restricted by their parents since childhood. Written permission from parents and family physicians for the girls to be excused from "gym" frequently accompanied medical records.

**DISCUSSION**

**Evaluation of Methods of Caloric Intake**

Assessment of the caloric intake of individuals is notoriously difficult. The difficulties are magnified when dealing with obese subjects, many of whom have either been on a diet or received dietary advice of one sort or another. Advertising and medical literature written for public consumption have increased calorie consciousness. Weighed food intakes, one-, and seven-day food records tend to underestimate the usual food intake. In studies with obese women it was demonstrated that the research dietary history method yielded individual caloric intakes averaging 600 to 900 calories per day higher than other methods tested. The Burke Research Dietary History Method was selected for use in this study because to test the importance of activity in relation to energy balance in obesity, it is essential not to bias results by minimizing an increased caloric intake.

Reliable estimates of caloric intakes of children and adolescents are also difficult to obtain. In the adolescent, variability of both food intake and physical activity is great. Interviews with obese adolescents require special care if the dietary histories are to be reliable. When one is dealing with a situation where the difficulties stemming from obesity and from the age of the subjects are combined, particular caution is required in the interpretation of the data.

**Evaluation of Activity Records**

Recounting activity schedules was a new experience for most of the girls. A wide range of individual physical activities was observed in each group of girls. It is recognized that the system of "activity indices" devised and used in this study is not a quantitative tool in the proper sense of the term. It does not pretend to give an accurate quantitative assessment of the calories expended for each hour by each girl, obese or nonobese. Quantitatively accurate data could only be obtained from prolonged direct or indirect calorimetric studies which are impractical to conduct under normal conditions of living. It seems, therefore, that the next best type of obtainable data, which can be collected without interfering with the usual routine, is the semiquantitative type of data collected in this study which represents a relative assessment of caloric expenditure of each girl's activity. The figures obtained by summation of these indices, although they cannot be translated into actual numbers of calories, can at least be expressed in ordinal fashion.

**Significance of Results**

As regards anthropometric findings, the earlier deceleration in height and a tendency toward earlier menarche found in this sample of obese girls suggest accelerated development and earlier maturation. "Obesity," at least as represented by Grid Channels A1 and A5, may have been in part simply an exaggeration of the stockiness, tendency to accumulate subcutaneous fat, and general feminine configuration which have been found to be associated with earlier maturation. Keys and Brozek have emphasized how precarious a definition of obesity from height-weight data can be, especially for individuals who do not differ too markedly from the "ideal."
ever, these girls are in the ordinary sense of the term "overweight" and the subjects in the higher Grid channels probably have an increasing fat content as compared to those in the middle channels and are, therefore, in the proper sense of the term "obese."

Perhaps the most striking impression is that these suburban high school girls are not physically active. Even the schedules of the nonobese group show little time devoted to household chores, little participation in active sports, and, at least during the school term, a minimum amount of time devoted to walking or other physical activity. Available facilities for sports are little used. However, even when the generally low level of activity is considered, the method of analysis used in this study still allows for the semiquantitative demonstration of clear-cut differences between the nonobese and obese groups.

Generally the obese girls spent less time in activities except those involving lying down or sitting than their controls. This was particularly true of strenuous exercises and sports. For example, 75 per cent of the obese girls and 90 per cent of their controls participated in ballroom dancing, but the control girls spent twice as much time dancing as the obese girls. Of the 28 control girls, two were cheer leaders and four were ballet or acrobatic dancers. None of the obese girls entered into these activities. In the competitive sports, an equal proportion of the girls in each group participated (60 per cent) but, again, among the participants, the nonobese girls averaged twice as much time for this type of activity as the obese. Twice as many of the nonobese girls bowled. Again, among bowlers, the control girls spent twice as much time as the obese players.

It appears that when the factors leading to obesity are studied, caloric intake and output due to activity must be considered simultaneously. When this is done, even though probable sources of error inherent in the interview method and in the type of activity analysis selected are recognized, it seems legitimate to conclude that in this sample of obese girls, inactivity is of greater importance than excessive food intake in the development of obesity. The difference in activity indices must symbolize a greater caloric output than the recorded difference in caloric intakes. The importance of exercise as a weight control factor in this population of high school girls is further demonstrated by the fact that a large proportion of the girls, both obese and nonobese, attended summer camps each year and almost without exception reported loss of weight under the system of enforced strenuous activity, in spite of simultaneous increased food intakes.

Although it is apparent that the obese group was not homogeneous with respect to the type of energy balance by which they achieved obesity, the largest number was characterized by "inactivity" rather than by "overeating." This exemplifies the proposition that, in studying obese patients, the whole mode of life rather than just one aspect, caloric intake, has to be taken into consideration. To say that obesity results from a positive energy balance is a tautology. To ascribe this positive energy balance to "overeating" and dismiss it from further analysis causes one to miss an essential characteristic of the etiology.

**SUMMARY**

Two groups of high school girls, 28 obese subjects and 28 nonobese individuals of similar height, age, and grade, were compared in regard to physical maturation, food intake, and activity.

The groups were found to differ in maturation, obese girls showing advanced development, i.e., earlier deceleration of growth in height and earlier menarche.

Activities were represented by a system of indices devised for this study. Both groups were found to be relatively inactive, but the obese girls were significantly more so.

When caloric intakes and activity indices were compared for each group to determine the salient energy factors in the development and maintenance of obesity, it appeared that on a statistical basis, inactivity was much more important than "overeating." In fact, the caloric intake of the obese group was significantly lower than that of the nonobese group, with the relatively greater energy balance being consequently supplied by inactivity.
REFERENCES


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**Magic and Mechanism in Medicine**

"The time may come when a patient can go through a diagnostic factory where the quantity of various difficulties is titrated mechanically. An answer comes out on ticker tape. This is then run through a vast therapeutical machine which throws just the proper proportion of every needed ingredient into the Mixmaster. This turns out pellets in a neat packet to be grasped by the hopeful but anonymous patient. He then will follow the printed guide, read eagerly like the fortune which emerges from the drugstore scales. Till this millennium comes we must keep up standards. The omens which indicate the direction of therapy today, a reversion to a quasitherapeutical horoscopy, point to a reversion to the polypharmacy which condoned combinations of puppy dog fat, powdered unicorn’s horns, dried mosquito wings, and spider webs, obtained from a graveyard in the dark of the moon, and brewed by witches as panacea for real and imagined ills of every kind."


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**Technologic Terms**

"We should demand that technologic words never be used in scientific papers if familiar words can be used instead. To give an example, I showed my colleague, the Professor of Anatomy, the following passage: ‘hypokalaemic hypochlorhaemic alkalosis was present.’ He had no idea what it meant. Had the statement read: ‘plasma potassium and chloride were diminished, CO₂ increased,’ he would have understood. Here the simpler phrase is seven letters more. But editors are not always so particular in curbing verbosity. Moreover, another example from a recent paper by a very able and highly cultured author, ‘bilateral nephrectomy was performed,’ is not only less easy for a non-biologic scientist to understand than ‘both kidneys were removed,’ but is also 11 letters longer. . . . When we use a technologic term there is a strong tendency for the idea to become isolated and inaccessible to those periodic spring cleanings to which we subject our more ordinary mental furniture. Thus, by using a technologic term we often assume an entity where in fact none exists; the next process is to invent it. Thus, by using a technologic term, we may create an artefact."