# Nutritional Management of Children With Diabetes Mellitus

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The maintenance diet of the child with diabetes mellitus should be essentially the same as for normal children.[1-8] We have had the unique opportunity of observing a large group of children with diabetes mellitus who have maintained a high degree of control of their disease throughout childhood. This was accomplished by using accurate doses of specific types of insulin in relation to the intake of a nutritionally complete diet adjusted to compensate for variations in physical activity. In this paper we shall present the caloric intake and growth curves for this group, compare the nutritional value of their diets with the 1953 recommended allowances of the National Research Council,[9] and discuss briefly the nutritional management of children with diabetes mellitus.

Forty-eight juvenile diabetics who maintained good control and attained normal growth, as measured by the Iowa growth charts,[10] were studied earlier to determine the insulin and caloric requirements in relation to age and growth.[11] The length of observation on a single subject ranged from three to eighteen years, the median for boys being seven years, nine months, and for girls seven years, eight months. To enlarge these serial data, observations from the records of five boys and six girls between the ages of one and six, and of twelve boys between twelve and eighteen years were included, making a total of 71 juvenile diabetics whose diets are evaluated.

In table 1 are listed the number of children studied and the number of observations at each age period. There are never more than two observations included for each subject in any yearly age group. The wide variation in number of data recorded at a single age and the number of years for which data are available are dependent on the age of onset of disease, the date of the first visit to this clinic, and the number of years during which the child maintained good diabetic control.

Both the parents and the children included in this study were given thorough instructions in dietary management. Periodic examinations were made at least every six months, at which time the diet was re-evaluated by the physician and the dietician. Any necessary changes were made so that the diet satisfied the appetite and was optimal for growth and development. The mothers of the diabetic children were instructed carefully at each clinic visit as to how to increase or decrease the caloric intake at any time necessary to meet the needs of the child. The foods were quantitated and records were kept. On days when more food was allowed for increased activity or less food was taken because of an infection or decreased activity, these changes were noted.

Tables 1 and 2 and figures 1 and 2 present the mean and standard deviations of the total caloric intake of the 39 boys and 32 girls. The total calories-per-day curves for the boys show a steady rise at least through age eighteen. The similar curves for the girls rise through age twelve, then level off and decline slightly. These caloric curves follow a pattern closely similar in slope to the standard height curves presented on the same charts. The average height and weight of the children, when plotted on the Iowa growth charts (figures 1 and 2), demonstrate that the boys and girls studied maintained normal growth. The individual growth charts based on serial observations showed no evidence of either undernutrition or overnutrition in any of the subjects.

In figure 3, the mean calories per pound of body weight for boys and girls are shown. It will be noted that the curves are almost identical through age ten. From one to three and one-half years the curves for calories per pound decrease rapidly; they level off until eight years of age, and then show a steady decline through adolescence. However, from age ten to eighteen, the calories per pound of body weight for girls decreased

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TABLE 1

Daily caloric requirements observed for boys

Mean and standard deviation of the total calories per day and the calories per pound of body weight per day for boys grouped according to age. The subjects are children with diabetes mellitus who maintained a high degree of control. The data also present mean heights and weights at the varying age groups to show that these children have grown normally.

| Age (years) | No. of boys | No. of observations | Mean height (inches) | Mean weight (pounds) | Total calories per day | | Calories per pound of body weight |
|---|---|---|---|---|---|---|---|
| | | | | | Mean | Standard deviation | Mean |
| 2 | 2 | 3 | 36.0 | 30.3 | 1275 | | 40.2 |
| 3 | 3 | 6 | 37.5 | 36.7 | 1350 | 88 | 35.4 |
| 4 | 8 | 14 | 41.0 | 42.1 | 1486 | 104 | 35.7 |
| 5 | 10 | 19 | 43.7 | 46.5 | 1631 | 86 | 34.0 |
| 6 | 10 | 18 | 46.7 | 53.4 | 1819 | 158 | 33.5 |
| 7 | 9 | 18 | 48.3 | 56.1 | 1858 | 239 | 32.9 |
| 8 | 11 | 22 | 50.8 | 62.0 | 2032 | 189 | 32.8 |
| 9 | 13 | 24 | 52.8 | 68.4 | 2113 | 192 | 30.9 |
| 10 | 13 | 26 | 55.3 | 77.9 | 2302 | 265 | 29.5 |
| 11 | 14 | 28 | 57.7 | 84.5 | 2383 | 231 | 27.7 |
| 12 | 16 | 32 | 59.6 | 93.0 | 2436 | 240 | 26.6 |
| 13 | 17 | 34 | 61.4 | 101.2 | 2599 | 254 | 25.6 |
| 14 | 18 | 36 | 63.9 | 112.8 | 2763 | 206 | 24.1 |
| 15 | 24 | 41 | 66.2 | 125.4 | 2930 | 285 | 23.7 |
| 16 | 21 | 42 | 67.7 | 135.2 | 3029 | 278 | 22.6 |
| 17 | 13 | 29 | 68.9 | 142.8 | 2977 | 328 | 21.0 |
| 18 | 11 | 22 | 70.1 | 154.4 | 2989 | 339 | 20.3 |

TABLE 2

Daily caloric requirements observed for girls

Mean and standard deviation of the total calories per day and the calories per pound of body weight per day for girls grouped according to age. The subjects are children with diabetes mellitus who maintained a high degree of control. The data also present mean heights and weights at the varying age groups to show that these children have grown normally.

| Age (years) | No. of girls | No. of observations | Mean height (inches) | Mean weight (pounds) | Total calories per day | | Calories per pound of body weight |
|---|---|---|---|---|---|---|---|
| | | | | | Mean | Standard deviation | Mean |
| 1 | 5 | 5 | | | 1015 | 250 | 48.8 |
| 2 | 4 | 8 | 34.1 | 28.1 | 1131 | 138 | 40.3 |
| 3 | 4 | 8 | 37.5 | 33.7 | 1244 | 96 | 36.0 |
| 4 | 8 | 16 | 40.1 | 38.5 | 1347 | 135 | 35.3 |
| 5 | 9 | 18 | 42.6 | 44.0 | 1467 | 158 | 33.2 |
| 6 | 10 | 20 | 45.0 | 48.6 | 1593 | 186 | 33.0 |
| 7 | 10 | 20 | 47.6 | 54.7 | 1782 | 243 | 32.9 |
| 8 | 12 | 24 | 50.0 | 60.2 | 1921 | 174 | 32.5 |
| 9 | 13 | 26 | 51.2 | 66.2 | 1981 | 171 | 30.4 |
| 10 | 14 | 28 | 53.8 | 72.7 | 2052 | 226 | 29.1 |
| 11 | 18 | 34 | 56.6 | 82.5 | 2156 | 229 | 26.7 |
| 12 | 19 | 37 | 59.0 | 90.2 | 2246 | 328 | 24.4 |
| 13 | 20 | 39 | 60.8 | 101.6 | 2241 | 272 | 22.3 |
| 14 | 20 | 36 | 62.7 | 111.8 | 2177 | 265 | 20.2 |
| 15 | 18 | 30 | 63.3 | 117.5 | 2074 | 306 | 18.2 |
| 16 | 16 | 28 | 64.0 | 124.4 | 2097 | 297 | 17.5 |
| 17 | 14 | 26 | 64.8 | 130.4 | 2133 | 264 | 16.5 |
| 18 | 9 | 18 | 65.3 | 132.4 | 2020 | 168 | 15.3 |

more rapidly than those for boys. Figures 4 and 5 for these same data represent the ranges of calories per pound of body weight for boys and girls. At most ages the range is fairly wide, which illustrates that the caloric needs of each child are variable, depending not only on age and sex but also on body build, rate of growth,

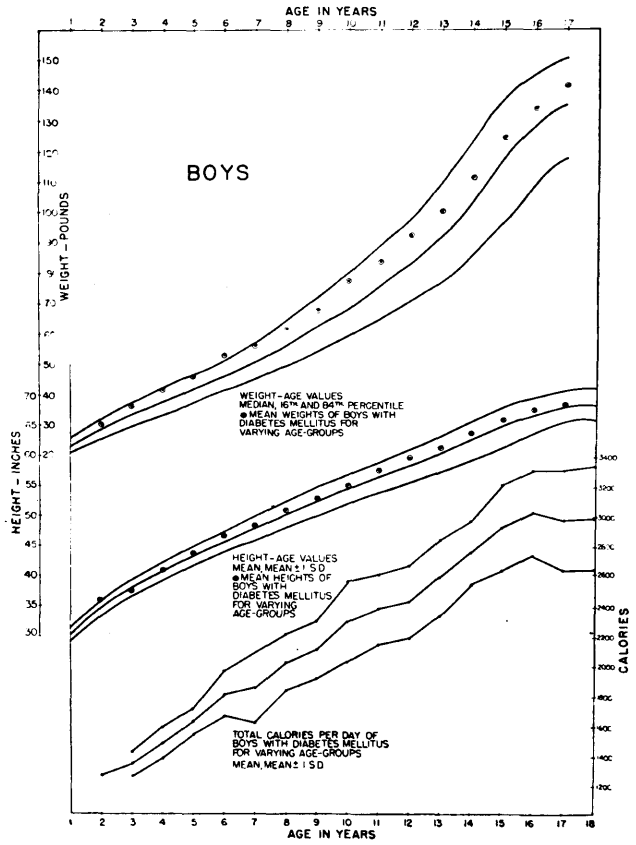


FIG. 1. Mean and standard deviation of total calories per day in relation to age for 39 boys with diabetes mellitus who maintained a high degree of control. Mean heights and weights of these same boys are plotted on the Iowa growth charts.

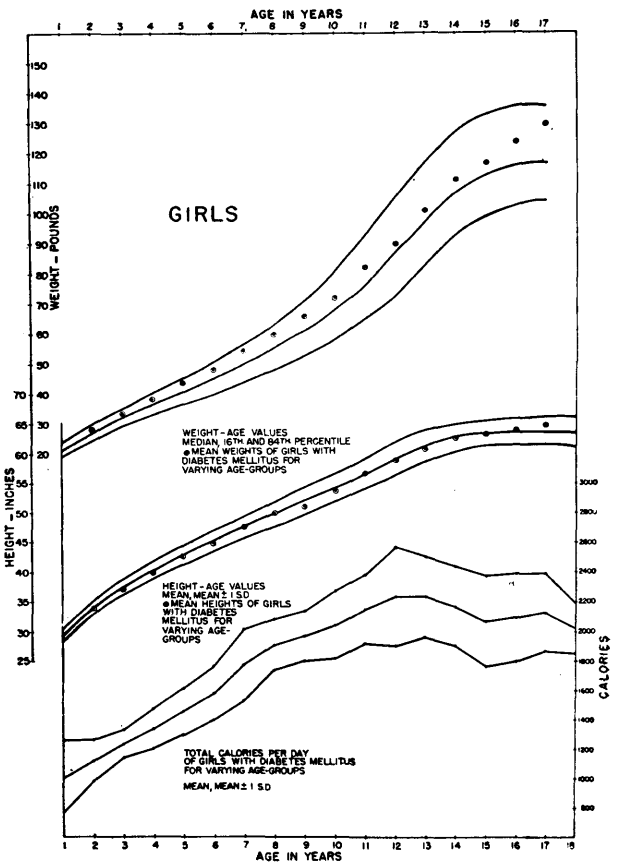


FIG. 2. Mean and standard deviation of total calories per day in relation to age for 32 girls with diabetes mellitus who maintained a high degree of control. Mean heights and weights of these same girls are plotted on the Iowa growth charts.

type and amount of activity, amount of rest, and emotional stress.

Tables 3 and 4 present the average daily nutrient intake of this group of diabetic boys and girls as compared with the daily dietary allowances recommended by the National Research Council (1953). It will be noted (starred values) that even though in several instances the caloric intake at a given age is lower than the NRC recommendations, the diets provide a more liberal allowance for protein, calcium, vitamin A, and riboflavin.

Figure 6 shows the curves of total and complete protein, that is, animal source protein, in the diets of the Iowa City boys as compared to the total and complete protein recommended by the NRC. Through age fifteen the complete protein available in the diabetic diets exceeds the total protein recommended. Likewise the total protein in our diets ranges from 16.5 to 18 per cent of the calories, as compared to 10.5 to 13 per cent in the NRC diets. The same relationship was found for the diets of the girls, and the curves are therefore not repeated here.

## DISCUSSION

In 1932 at the White House Conference on Child Health and Protection[12] values for mean total calories per day were reported from studies including 253 boys and 243 girls. These data served as the basis for the caloric allowances recommended by the National Research Council. Since that time, dietary studies have shown that the calories furnished by the American diet very frequently are considerably below the NRC recommendations.[13] In the present study of 71 diabetic children who sustained essentially physiologic control and grew normally, the total caloric intakes of both boys and girls are much the same as the White House Conference data up to adolescence. However, from ages thirteen through eighteen for the girls and sixteen through eighteen for

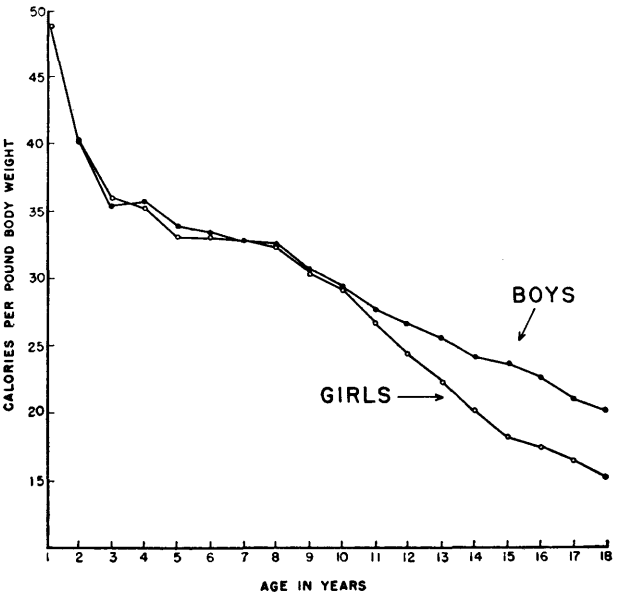


FIG. 3. Mean calories per pound of body weight in relation to age for 39 boys and 32 girls with diabetes mellitus in good control.

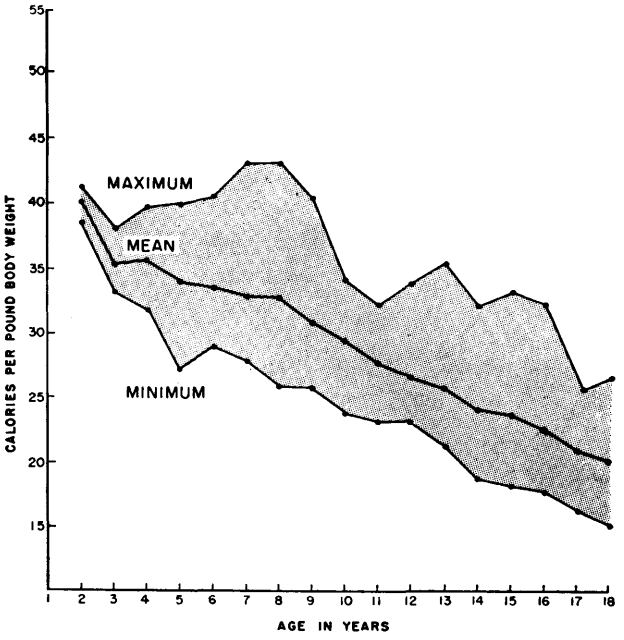


FIG. 4. Range of calories per pound of body weight in relation to age for 39 boys with diabetes mellitus in good control.

TABLE 3

Diabetic diets for boys

Diets used for boys in Iowa City Diabetic Clinic compared to daily dietary allowances recommended by the National Research Council (1953)

| Age | Calories | | Protein Gm. | | Calcium Gm. | | Iron Mg. | | Vitamin A I.U. | | Thiamine Mg. | | Riboflavin Mg. | | Ascorbic Acid Mg. | | Vitamin D I.U. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Iowa | NRC | Iowa | NRC | Iowa | NRC | Iowa | NRC | Iowa | NRC | Iowa | NRC | Iowa | NRC | Iowa | NRC | Iowa | NRC |
| 1-3 | 1200 | 1200 | 55* | 40 | 1.1* | 1.0 | 7 | 7 | 4700 | 2000 | 0.8 | 0.6 | 1.8* | 1.0 | 110 | 35 | 400 | |
| 4-6 | 1500* | 1600 | 65* | 50 | 1.4* | 1.0 | 8 | 8 | 5300 | 2500 | 1.0 | 0.8 | 2.2* | 1.2 | 95 | 50 | 400 | |
| 7-9 | 2000 | 2000 | 90* | 60 | 1.7* | 1.0 | 11 | 10 | 6600 | 3500 | 1.4 | 1.0 | 2.8* | 1.5 | 155 | 60 | 400 | |
| 10-12 | 2400 | 2500 | 105* | 70 | 1.9* | 1.2 | 13 | 12 | 8500 | 4500 | 1.6 | 1.3 | 3.1* | 1.8 | 165 | 75 | 400 | |
| 13-15 | 2700* | 3200 | 115* | 85 | 2.4* | 1.4 | 14 | 15 | 9000 | 5000 | 1.7 | 1.6 | 3.6* | 2.1 | 165 | 90 | 400 | |
| 16-20 | 2900* | 3800 | 120* | 100 | 2.5* | 1.4 | 16 | 15 | 9000 | 5000 | 2.0 | 1.9 | 3.8* | 2.5 | 200 | 100 | 400 | |

TABLE 4

Diabetic diets for girls

Diets used for girls in Iowa City Diabetic Clinic compared to daily dietary allowances recommended by the National Research Council (1953)

| Age | Calories | | Protein Gm. | | Calcium Gm. | | Iron Mg. | | Vitamin A I.U. | | Thiamine Mg. | | Riboflavin Mg. | | Ascorbic Acid Mg. | | Vitamin D I.U. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Iowa | NRC | Iowa | NRC | Iowa | NRC | Iowa | NRC | Iowa | NRC | Iowa | NRC | Iowa | NRC | Iowa | NRC | Iowa | NRC |
| 1-3 | 1100* | 1200 | 55* | 40 | 1.1* | 1.0 | 7 | 7 | 4400 | 2000 | 0.8 | 0.6 | 1.8* | 1.0 | 110 | 35 | 400 | |
| 4-6 | 1400* | 1600 | 60* | 50 | 1.4* | 1.0 | 7 | 8 | 5300 | 2500 | 0.9 | 0.8 | 2.1* | 1.2 | 95 | 50 | 400 | |
| 7-9 | 1900 | 2000 | 80* | 60 | 1.5* | 1.0 | 10 | 10 | 6000 | 3500 | 1.2 | 1.0 | 2.4* | 1.5 | 140 | 60 | 400 | |
| 10-12 | 2200 | 2300 | 100* | 70 | 1.9* | 1.2 | 12 | 12 | 6900 | 4500 | 1.4 | 1.2 | 3.0* | 1.8 | 140 | 75 | 400 | |
| 13-15 | 2200* | 2500 | 100* | 80 | 1.9* | 1.3 | 12 | 15 | 6900 | 5000 | 1.4 | 1.3 | 3.0* | 2.0 | 140 | 80 | 400 | |
| 16-20 | 2000* | 2400 | 90* | 75 | 1.7* | 1.3 | 11 | 15 | 6500 | 5000 | 1.4 | 1.2 | 2.8* | 1.9 | 140 | 80 | 400 | |

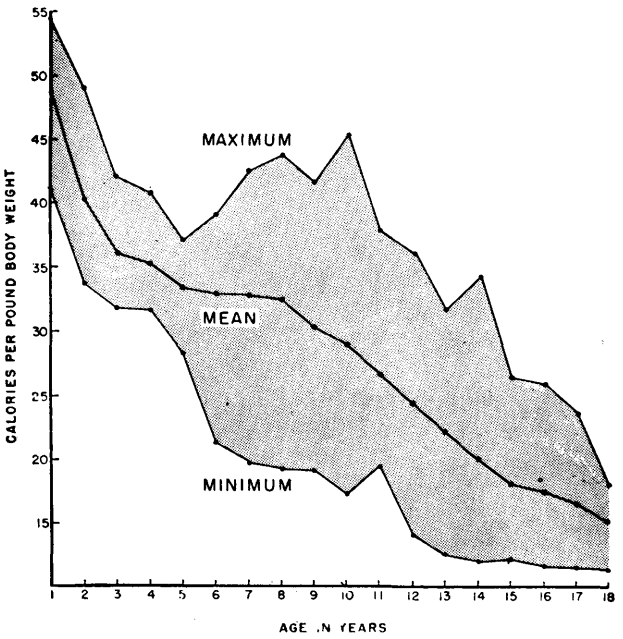


FIG. 5. Range of calories per pound of body weight in relation to age for 32 girls with diabetes mellitus in good control.

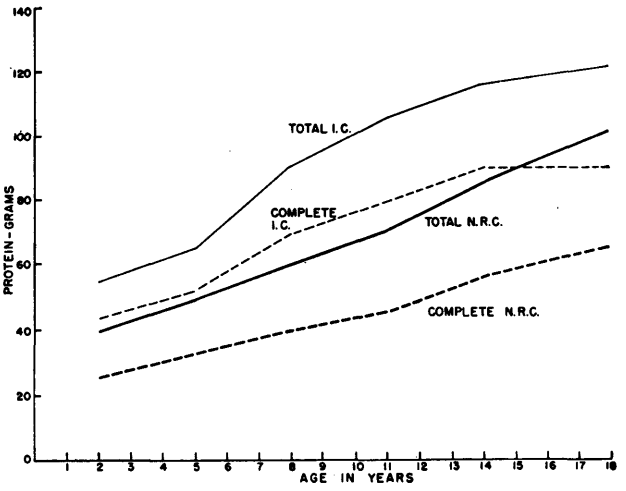


FIG. 6. Curves of total and complete protein in the prescribed diets of Iowa City (I.C.) boys at varying ages as compared to the total and complete protein in diets recommended by the National Research Council (NRC). The complete protein for the I.C. diets is the animal protein calculated from typical diets appropriate for given ages. The NRC complete protein has been calculated as 2/3 of the total protein values for each age.

the boys, these children receiving semi-quantitated diets have somewhat lower caloric intakes. As mentioned previously, so many factors determine the total caloric requirement that very large deviations from the mean intake must be expected. The wide range in caloric intake (figures 4 and 5) at a particular age for both boys and girls demonstrates that intake must be governed by variations in activity and stage of maturation in order to sustain normal growth. Therefore it is not possible to predict exactly the caloric requirement of any given child, but the general pattern or curve that this intake will follow can be anticipated.

This knowledge is particularly useful in guiding the intake of adolescent girls to prevent the overweight frequently noted during this period. For girls after the age of twelve years, the mean total calories-per-day curves reflect a decreased intake, and the calories-per-pound curve for girls during postpubescence shows a rapid and steady decline. Some of the factors involved in the usual accelerated weight gain are failure to decrease insulin and caloric intake after the prepuberal growth spurt, decreased physical activity, and dietary indiscretions to attain social acceptance. Since these girls were receiving weighed diets and their growth and weight gain were being evaluated every three to six months, it was possible to advise decreasing the caloric intake before the overweight became excessive.

A tendency to overweight did not appear in the boys, the total calories-per-day curves showing a steady upward trend through adolescence. Boys continue to add weight during late adolescence after height growth has been essentially completed; also, the amount of physical activity of boys frequently increases.

We realize that figures 1 and 2, which give mean total caloric intake for boys and girls, should be used only as a general guide, since a wide range is to be expected due to the adjustment of the diet, primarily for varying physical activity. A discussion of physical activity in juvenile diabetics has been presented by Jackson and Kelly,[14] who point out that during short periods of increased exercise it is better to give additional food than to decrease the amount of insulin to compensate for the increased physical activity. Normal children may be expected to have increased appetites and to take extra food for exercise so that their needs for growth will continue to be met. The same is true for the well regulated diabetic child, and with instruction and experience these children and their parents have learned how to adjust their diets and still maintain essentially physiologic control of their disease.

Recent research by a group of workers at Columbia University[15, 16] has given us some data on energy expenditure by children for specific activities. These data aid in demonstrating that caloric intake might well in-

crease several hundred calories a day to meet the needs of periods of strenuous activity. For example, Taylor[15] states that boys of twelve to fourteen years of age would require 2.1 cal. per kg. per hr. for quiet play, with an increase to 4.5 cal. per kg. per hr. for cycling. The mean value for energy expenditure for the routine activities of the twelve- to fourteen-year-old diabetic on this study is 2.6 cal. per kg. per hr. An increase of 1.9 cal. per kg. per hr. would bring the calories up to Taylor's requirement for cycling. For a thirteen-year-old boy of average weight, 42 kg., this would add an energy expenditure of 80 cal. per hr. Four hours of work at this rate of expenditure would add approximately 320 calories to the day's needs. Therefore the predicted mean total caloric intake for a thirteen-year-old boy might increase from 2600 to 3000 calories or more on a day when physical activity is increased. It is obvious that exercise is an extremely important factor in determining total caloric needs; therefore the curves presented here should be used only as a general guide and should be individualized for each patient.

It should also be pointed out that the mean calories per pound of body weight have been calculated from caloric intakes and weights of well regulated diabetic children. These calculations represent their everyday maintenance and growth requirements. The caloric needs of a newly discovered diabetic who has become undernourished with the onset of the disease or is not fully utilizing his food would be expected to be higher than the maintenance requirements for a well regulated child, since there is a need to rebuild body tissues and replenish body stores. Once good nutritional status has been re-established and growth is following a fairly normal pattern, caloric requirements can be estimated by these mean calories-per-pound figures. However, if a child is either overweight or underweight the theoretical weight for his height rather than his actual weight should be used as a guide in predicting caloric intake.

As stated earlier, the diets for children with diabetes mellitus should approximate the diets for normal children. However, considerable emphasis has been placed on the use of a higher protein diet for diabetics. The main effect of diabetes on protein metabolism appears to be a decreased rate of muscle protein synthesis. In untreated severely diabetic animals, this decrease in formation rate may be as high as 60 to 80 per cent.[17] In the studies of the effects of protein on blood sugar levels of diabetic patients, Till[18] confirmed the importance of protein in maintaining an even distribution of sugar in the blood. Schwarz[19] has stated that a high-protein diet may be valuable in the prevention and treatment of diabetic retinopathy. Fanconi and others[20] report an extremely high incidence of nephropathies in a group of juvenile diabetics given a low-protein diet.

Almost all juvenile diabetic patients are labile and at times do not maintain a high degree of control of their disease. A higher protein intake is therefore advised to re-establish the nutritional state after periods of incomplete control, to provide greater satiety value in the diet, to help maintain more even distribution of sugar in the blood, and possibly to retard the development of degenerative changes.

The requirements for water-soluble vitamins such as thiamin may also be higher for the diabetic patient during periods of incomplete control. Ott[21] reports that larger amounts of thiamin are excreted by diabetic rats than by normal rats. Myers,[22] working with diabetic children and young adults, found that the diphosphothiamin fraction of the blood was somewhat lower among diabetics, particularly among poorly controlled patients.

Nutritional management of the diabetic child implies not only the what or why of the diet but also the how. To provide a liberal diet, rich in protective foods and adjusted to meet the needs of each individual child, is the first objective of dietary management. As reported by Jackson and Kenefick,[4] the diet is calculated on the basis of protein and calories, and no special attention is given to the fatty acid:dextrose ratio of individual meals. The diets are liberal, permitting a wide variety of foods, but excluding concentrated sweets. Frequently the nutrition of the entire family is improved by using the diabetic's meal pattern.

Many hours of teaching and demonstration were spent with each family so that the fundamentals of good nutrition could be learned and applied to every member of the family. In the beginning, in order to learn the caloric content of different portions of a food, the mother and diabetic child were taught how to weigh all the foods for the diet. Soon the mother learned to estimate the foods that appeared daily in the meals. Then, recipes combining the basic foods used in the diet were given to the patients, which added variety to the meals and stimulated individual interest. Finally, the patients were instructed in the use of the diabetic diet exchange lists[23] to prepare them to fit into the diet pattern widely used by adult diabetics. They were frequently reminded, throughout their training, of the need to increase or decrease the diet to compensate for differences in physical activity. In addition they were taught how to adjust the basic diet according to the appetite and rate of growth.

In recent years, with the use of longer-acting types of insulin, the diet pattern of the diabetic has simulated the usual dietary habits of well-fed nondiabetic children. The diabetic is given prescribed lunches to take between meals; this provides greater opportunity to increase or decrease food intake for daily variations in physical activity and also helps the social adjustment of the child.

Controversy still exists as to whether the diet should be given quantitatively and at specific periods during the day, or whether the child should simply be allowed to eat a supervised diet. The introduction of the term "free diet" has resulted in considerable confusion, since the term is interpreted differently by different people. In our opinion it is not desirable to permit any child, diabetic or otherwise, to eat without some supervision and direction. A large percentage of American children are receiving inadequate diets because of excessive intakes of unessential foods. This type of eating pattern should be discouraged for all children. The only difference in the dietary program for the diabetic as compared to the nondiabetic child, according to our regimen, is that we plan the diet so that he has a predictable intake given in the proper relationship to the type and amount of insulin that has been administered to avoid glycosuria and insulin reactions.

None of the patients included in this study had any clinical evidence of vascular disease. As part of a current study of degenerative changes in juvenile diabetics, we have been carefully reviewing at this clinic the dietary habits of patients who have had their disease for more than ten years. The data clearly show that those patients who have established good nutritional habits during childhood have, with few exceptions, carried these habits into adult life. Furthermore, there is an extremely low incidence of hypertension and albuminuria even in some of the patients who have not maintained a high degree of control as judged by glycosuria. It may well be that the lowered incidence and severity of degenerative changes in our patients may be related to their good dietary habits.

## SUMMARY

A serial study of caloric intakes of 71 juvenile diabetics who sustained normal growth is presented. This information taken during childhood and adolescence has added to our understanding of the total energy requirements of boys and girls, the caloric requirements per pound of body weight, the differences in requirements for sex and activity, and the need for a reduction in calories for girls shortly after maturation. Curves based on the mean and standard deviaton of total calories per day for varying age groups and the mean calories per pound of theoretical body weight have been derived from these data and may be used as a general guide for caloric requirements for children and adolescents.

A comparison of the nutritive value of the diabetic diets with the allowances recommended in 1953 by the National Research Council illustrates that, even though caloric intakes in general are lower than those recommended, the diets provide a more liberal allowance of protein, calcium, vitamin A, and riboflavin.

The maintenance diet for the diabetic child should be essentially the same as for the well-fed normal child; and in our opinion the diet should be planned quantitatively, with foods given at specific periods during the day. The diet should be individualized to meet the varying needs of growth, physical activity, and maturation pattern of each child. Inasmuch as it is impossible to maintain complete diabetic control at all times, a slightly higher intake of protective foods is advised to provide some margin of safety.

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## SUMMARIO IN INTERLINGUA

### *Regime Nutritional pro Infantes con Diabete Mellite*

Es presentate un studio serial del rationes caloric de 71 diabeticos juvenil qui manteneva un crescentia normal. Le information hic colligite ab juveniles e adolescentes augmenta nostre comprension del requirimentos de energia total in pueros e pueras, del requirimentos caloric per libra de peso corporee, del differentias inter le requirimentos pro le duo sexos e pro varie grados de activitate, e del necessitate de reducer le ration caloric de pueras brevemente post lor maturation. Nos ha utilisate nostre datos in le elaboration de curvas del deviation median e standard del rationes caloric total per die pro varie etates e del ration caloric median per libra de peso corporee theoric. Iste curvas es usabile como guidas general pro determinar le requirimentos caloric de juveniles e adolescentes.

Nos ha comparate le valor nutritive del dietas diabetic in nostre serie de casos con le recommendationes publicate in 1953 per le Consilio National de Recerca. Iste comparation indica que le rationes caloric in nostre serie esseva generalmente inferior al recommendation del Consilio sed que le provision de proteina, calcium, vitamina A, e riboflavina esseva superior.

Le dieta currente pro juveniles diabetic deberea esser essentialmente identic con illo de ben-alimentate juveniles normal. In nostre opinion, le dieta del juveniles diabetic deberea esser planate quantitativemente con alimentos prendite a periodos specific del die. Le dieta deberea esser individualisate pro satisfacer le varie requirimentos de differente combinationes de crescentia, typos de activitate, e maturation. A causa del impossibilitate de un complete e nunquam interrumpite controlo diabetic nos recommenda un leve augmento de alimentos protective pro provider un certe margine de securitate.