CALORIE CONTROL

A NEW DIETETIC TREATMENT OF DIABETES MELLITUS

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Before the discovery of insulin the treatment of diabetes mellitus was essentially dietetic. It consisted in a severe restriction of the total calorie value of the food, with a relatively high proportion of protein and fat and a low proportion of carbohydrate. Subsequently a change in the diet of the diabetic patient requiring insulin was effected very slowly; indeed, 10 years after the discovery of insulin many patients were still being given diets similar to those of the pre-insulin period. In the last 10 years or so they have generally been allowed to increase the total calorie intake and the proportion of carbohydrate to protein and fat. It has long been our custom to give patients who are not excessively obese a diet which corresponds as nearly as possible to that which each individual might be expected to take if he had not got diabetes mellitus. The patient is encouraged to say if the diet is adequate or not, and adjustments are made accordingly. The total intake of carbohydrate, protein, and fat is controlled so that it does not vary from day to day, and the amount of insulin required to balance the patient is then determined by trial.

The dietetic restrictions necessitated by war have demanded a reconsideration of the problem of diabetic diets. The Government has allowed diabetic patients extra protein and fat but less sugar, yet it has not been possible for them to continue with their pre-war diets. In June, 1941, we began to try a new diet system which aimed at keeping the total calorie value of the food constant from day to day while allowing complete freedom of choice of food. Thus the patient can take a protein-and-fat breakfast of bacon one day and a carbohydrate breakfast of cereal the next. The new diet has proved to be very much easier for the diabetic to use, because the system eliminates the necessity for dividing different foods into carbohydrate, protein, and fat varieties, and because a much wider choice is available for each meal.

The Diet

TABLE I.—Sample Diet of 2,000 Calories

Breakfast (450 calories):	Calories
Tea or coffee, with milk $\frac{1}{2}$ pint	50
Oats or cornflakes, 1 oz.	100
Bacon, 1 oz.; or 1 egg plus $\frac{1}{2}$ oz. margarine or butter ..	150
Bread, $1\frac{1}{2}$ oz.	100
Butter, $\frac{1}{2}$ oz.	50
Mid-morning.—Tea or coffee, with milk $\frac{1}{2}$ pint, and 1 biscuit ($\frac{1}{2}$ oz.) ..	75
Dinner (500 calories):	
Lean meat, cheese, or fish to the value of	150
Fat meat or butter, $\frac{1}{2}$ oz.	50
Cabbage, cauliflower, sprouts, leeks, marrow, onions, lettuce, tomatoes, or radishes as desired	—
Potatoes, 4 oz.	100
Bread, $\frac{1}{2}$ oz., or vegetables to the value of	50
Rice, tapioca, or sago, $\frac{1}{2}$ oz., or fruit to the value of ..	50
Milk, $\frac{1}{2}$ pint	100
Tea (425 calories):	
Milk, $\frac{1}{2}$ pint in tea	50
Bread, 3 oz.	200
Butter or margarine, $\frac{1}{2}$ oz.	50
Jam, 1 oz.	75
2 plain biscuits ($\frac{1}{2}$ oz.)	50
Supper (550 calories):	
Fish, cheese, or meat to the value of	150
Potatoes, 4 oz.	100
Vegetables as at dinner	—
Bread, $2\frac{1}{2}$ oz.	150
Butter, $\frac{1}{2}$ oz.	50
Fruit to the value of	50
Milk, $\frac{1}{2}$ pint in tea or coffee	50

You can take the whole of your dinner in the form of sandwiches: bread 3 oz., butter $\frac{1}{2}$ oz., meat or cheese to the value of 150 calories; milk, $\frac{1}{2}$ pint. In a temporary emergency you can take each of your four meals in the form of bread—five 1-oz. slices, and butter or margarine $\frac{1}{2}$ oz.

If you are unwell and cannot eat your usual diet continue to take your habitual dose of insulin at the usual time and, in place of each of your four meals, take 20 lumps of sugar in tea or water.

The principle of the diet is to arrange each meal on the basis of a given number of units of food each equivalent to 50 calories. The patient is given a sample diet of 2,000 calories, which is typed on a sheet of foolscap paper (Table I). The diet can be readily increased by adding other units on the dotted lines provided for this purpose beneath each meal, or reduced by striking out unwanted units. On the reverse side of this diet sheet is typed a large variety of alternative foods in alphabetical order (Table II). Against each food

TABLE II.—The Following Quantities of Food each yield 50 Calories

	oz.		oz.
Apples, English eating, with skin and core	4 $\frac{1}{2}$	Raspberries, raw	6 $\frac{1}{2}$
" cooking, raw	4 $\frac{1}{2}$	Rice	2 $\frac{1}{2}$
" stewed without sugar	8 $\frac{1}{2}$	Sago	2 $\frac{1}{2}$
Apricots, dried, stewed without sugar	2 $\frac{1}{2}$	Strawberries, raw	6 $\frac{1}{2}$
" fresh	5 $\frac{1}{2}$	Sugar	2 lumps
Arrowroot	$\frac{1}{2}$	Sultanas	$\frac{1}{2}$
Bananas, without skin	2	Swedes, boiled	10
Beans, baked	1 $\frac{1}{2}$	Tapioca	$\frac{1}{2}$
" broad, cooked	4	Tomatoes	12 $\frac{1}{2}$
" butter, boiled	1 $\frac{1}{2}$	Cheese	
Beetroot, boiled	3 $\frac{1}{2}$	Cheddar	$\frac{1}{2}$
Biscuits	$\frac{1}{2}$	Dutch	$\frac{1}{2}$
Blackberries, raw	5 $\frac{1}{2}$	Gorgonzola	$\frac{1}{2}$
Bournvita	$\frac{1}{2}$	St. Ivel	$\frac{1}{2}$
Bread	$\frac{1}{2}$	Fats	
Carrots, boiled	8 $\frac{1}{2}$	Butter	$\frac{1}{2}$
" raw	7	Clotted cream	$\frac{1}{2}$
Cherries, cooking, raw, with stones	4	Cream	$\frac{1}{2}$
" eating, with stones	4	Margarine	$\frac{1}{2}$
Cocoa	$\frac{1}{2}$	Meat fat	$\frac{1}{2}$
Cornflour	$\frac{1}{2}$	Fish	
Cranberries	10	Bloater, with bone and skin	1
Currants, black, raw	5 $\frac{1}{2}$	Cod, steamed	2 $\frac{1}{2}$
" red, raw	7	Eel, stewed, with bone	1
" dried	$\frac{1}{2}$	Haddock, smoked and fresh	1 $\frac{1}{2}$
Custard powder	$\frac{1}{2}$	Hake	1 $\frac{1}{2}$
Dates, without stones	$\frac{1}{2}$	Kipper, with bone and skin	1 $\frac{1}{2}$
Figs, dried, raw	$\frac{1}{2}$	Lemon sole, steamed	2
Flour	$\frac{1}{2}$	Mackerel, fried	1
Golden syrup	$\frac{1}{2}$	Plaice, steamed	2
Gooseberries, dessert	4 $\frac{1}{2}$	Salmon, fresh	1
Grapes, black	3	" tinned	1 $\frac{1}{2}$
" white	2 $\frac{1}{2}$	Sardines	$\frac{1}{2}$
Honey	$\frac{1}{2}$	Skate, fried	$\frac{1}{2}$
Horlick's	$\frac{1}{2}$	Sole, steamed	2
Jam	$\frac{1}{2}$	Whiting	2
Kellogg's cornflakes, All-Bran	$\frac{1}{2}$	Meat	
Leeks, boiled	7	Beef, sirloin, lean, roast	$\frac{1}{2}$
Lentils, raw	$\frac{1}{2}$	" steak, stewed	$\frac{1}{2}$
Loganberries, raw	10	Chicken	1
Macaroni	$\frac{1}{2}$	Corned beef	$\frac{1}{2}$
Marmalade	$\frac{1}{2}$	Duck	$\frac{1}{2}$
Melon, yellow, with skin	12 $\frac{1}{2}$	Goose	$\frac{1}{2}$
Milk ($\frac{1}{2}$ pint)	2 $\frac{1}{2}$	Ham, boiled, lean	$\frac{1}{2}$
Oatmeal	$\frac{1}{2}$	Kidney, sheep, raw	1 $\frac{1}{2}$
Oats, Quaker	$\frac{1}{2}$	Liver, fried	$\frac{1}{2}$
Onions, boiled	12 $\frac{1}{2}$	Mutton chop, lean, raw, with bone and fat	2 $\frac{1}{2}$
" spring, raw	4 $\frac{1}{2}$	" leg, roast	$\frac{1}{2}$
Orange juice	4	" scrag neck, stewed	$\frac{1}{2}$
Oranges, without peel or pips	4 $\frac{1}{2}$	Pork, leg, roast	$\frac{1}{2}$
Ovaltine	$\frac{1}{2}$	Rabbit, stewed	1
Parsnips, boiled	3	Tongue	$\frac{1}{2}$
Peaches, dried, raw	$\frac{1}{2}$	Tripe, stewed	2
" fresh	4 $\frac{1}{2}$	Turkey	1
Pears, cooking, stewed without sugar	6 $\frac{1}{2}$	Veal, fillet, roast	$\frac{1}{2}$
" eating	4 $\frac{1}{2}$		
Peas, dried, boiled	1 $\frac{1}{2}$	Egg: 50 calories	
" fresh, boiled	3 $\frac{1}{2}$	Bacon: 1 oz. fried—150 calories	
Pineapple, fresh	3 $\frac{1}{2}$		
Plums, eating, with stones	4 $\frac{1}{2}$	Unlimited amounts of the following:	
" cooking, raw, with stones	7	Asparagus, brussels sprouts, cabbage, cauliflower, celery, cucumber, endive, French beans, globe artichoke, gooseberries (stewed without sugar), lettuce, lemon juice, mushroom (stewed), mustard and cress, rhubarb (stewed without sugar), spinach, turnip tops, watercress.	
Potatoes, boiled	2		
" chip	$\frac{1}{2}$		
Prunes, stewed without sugar	2 $\frac{1}{2}$		
Raisins	$\frac{1}{2}$		
Raspberries, stewed without sugar	10		

is given the amount, in ounces, which yields approximately 50 calories. These figures are based on the food values given by McCance and Widdowson (1940).

Results of Treatment

We have examined the records of all cases which have attended the diabetic departments of the London Hospital and Oldchurch Hospital since September 1, 1941. We chose this date because it was the day on which we first began to treat large numbers of cases with the new diet. Altogether 766 patients have attended, and 528 of these are using the calorie control diet. The cases have been subdivided into groups, which will be referred to as severe, mild, and old. All cases requiring 60 or more units of insulin daily have been classed as severe. Cases under 60 years of age requiring less than 60 units of insulin a day have been classed as mild. Cases aged 60 years or more requiring less than 60 units of insulin a day have been classed as old. The group of 528

cases using the calorie control diet have thus been subdivided as follows:

(A) Cases requiring insulin	477
Severe	107
Mild	239
Old	131
(B) Cases not requiring insulin (all ages)	51

The general health of the patients in all groups has been as good on the new diet as on the old. There has been no increase in the frequency of insulin reactions or of diabetic coma; indeed, some of the most unstable cases have been more stable on the new diet. The difference in efficiency which exists between the calorie control diet and the old one is slight, and an accurate estimate of it can only be made by comparing the condition of each patient before and after starting the new diet. We decided, therefore, to take for this comparison only those cases requiring insulin which had attended the clinics regularly for a period of three months before and three months after first receiving the new diet. This excluded a large number of fresh cases which started using the new diet at the beginning of their treatment, many old cases which had not been seen for a long time owing to evacuation or other causes and which started the new diet immediately they returned, and some patients who did not attend regularly. Altogether only 192 out of 477 cases requiring insulin were suitable for further analysis. In this group a comparison was made between the body weight, insulin requirement, and amount of glycosuria during the three months before and the three months after starting the new diet. The results have been recorded as increased, unchanged, or decreased—representing the change that has occurred since the diet was altered. They are shown in Table III, in which the figures represent the number of cases in each group.

TABLE III

	Cases		Weight	Insulin	Glycosuria
Severe	47	Increased	20	24	7
		Unchanged	19	10	27
		Decreased	8	13	13
Mild	92	Increased	46	36	7
		Unchanged	37	29	58
		Decreased	9	27	27
Old	53	Increased	20	25	8
		Unchanged	20	22	32
		Decreased	13	6	13
Total	192	Increased	86	85	22
		Unchanged	76	61	117
		Decreased	30	46	53

The figures show a significant increase in the body weight in all groups. The number of cases requiring more insulin is nearly double the number of those requiring less, but there is a significant decrease in the amount of glycosuria in all groups. The changes in body weight and in the amount of glycosuria are therefore satisfactory, but the increase in the amount of insulin required might appear at first to be an unsatisfactory feature. Actually this is not so, because there is a natural tendency for diabetic patients to need more insulin in the course of time. We investigated the alteration in insulin requirements during a similar period of six months in a group of 100 unselected cases which were having the old type of diet throughout this period. In 39 cases the insulin requirement had increased, in 34 it was unchanged, and in 27 it had decreased. These figures may be compared with the figures in Table III. In the whole group of 192 cases the insulin requirement had increased in 44%, was unchanged in 32%, and had decreased in 24%. Another explanation of the increased insulin requirement is to be found in the greater total calorie value of the new diet compared with the old one. We analysed the calorie value of the diets in all the 192 cases requiring insulin and recorded it as increased when the new diet was more than 50 calories in excess of the old one, unchanged when it was within 50 calories of the old one, and decreased when it was less than the old one by more than 50 calories. We found that the diet had been increased in 98, was unchanged in 58, and had been decreased in 36 cases. We then compared the number of cases in each group with the change in insulin requirement; the results are

shown in Table IV, the figures representing the number of cases in each group.

TABLE IV

	Insulin		
	Increased	Unchanged	Decreased
Diet increased	49	30	19
" unchanged	21	18	19
" decreased	15	13	8

In the group in which the calorie value of the diet had been raised the insulin requirement had increased markedly, but in the other two groups it had increased only slightly. This increase is less than would be anticipated from a comparison with the above-mentioned 100 cases, whose insulin requirement was observed for a period of six months while they were on the old diet.

Discussion

There is no adequate explanation of the effectiveness of the calorie control diet that can be based on our present knowledge of the physiological action of insulin. It is often assumed that when the carbohydrate value of a diet is increased the insulin requirement will also be increased. The idea conforms with the old conception that a fixed amount of insulin is necessary to utilize a fixed amount of carbohydrate. Actually when the carbohydrate value of a diet is raised the insulin requirement generally falls, provided the total calorie value of the diet is not altered. This effect was shown in a remarkable way by Prof. Ellis at the London Hospital in 1934. He found that severe cases of diabetes mellitus receiving daily 600 g. of glucose alone developed a marked temporary improvement in carbohydrate tolerance, necessitating the use of smaller doses of insulin. In the most notable instance in his series the reduction of insulin was from 192 units daily before the administration of glucose to 9 units daily on the twenty-first day after this treatment was begun. This interesting observation has received scant attention; but it forms a rational basis for the present treatment of diabetic coma with 4-hourly glucose and insulin, and offers an explanation of the effectiveness of our calorie control diet. It explains why the insulin requirement is actually less than anticipated in those cases in which the calorie value of the new diet is the same as that of the old one. It even suggests that patients might become reactionary as a result of taking the extra carbohydrate which is made available to them, but there has been no increase in the number of reactions reported by our cases.

The rate of change in the carbohydrate tolerance which occurs when carbohydrate foods are interchanged with protein and fat foods of the same calorie value by patients using the new diet is not rapid enough to cause instability, but in order to test the extent of permissible variation in the proportion of carbohydrate to protein and fat in the daily diet an experiment was undertaken at Oldchurch Hospital. Eight cases were chosen, including three of the most unstable diabetic patients attending either hospital. Each case was treated as an in-patient and was given a diet in which the proportion of carbohydrate, protein, and fat was kept constant at a normal level. The patients were made as stable as possible with insulin. The diet was then changed to an almost completely carbohydrate one of the same calorie value for two days. After this for another two days it was altered to one of the same calorie value consisting mainly of protein and fat. The carbohydrate diet was then repeated for two more days and the protein and fat one for a further two days. After this the patients returned to their normal diet. The blood sugar was estimated every two hours for 12 hours at the beginning of the experiment while the patient was on a normal diet. This was repeated on the second day after each subsequent change of diet, ending on the second day after returning to normal diet again. The six blood-sugar curves thus obtained were compared, and it was found that the range of values was of the same order in each case. The variation in the proportion of carbohydrate, protein, and fat in these diets was far greater than is ever likely to occur under normal circumstances. The experiment confirmed our belief that the unlimited interchange of these different foods which is allowed

by the new diet is permissible even for the most unstable diabetic patients.

The calorie control diet has proved to be as satisfactory in every way as the older type of diet in use in these clinics. It is more simple to use, and it allows patients to replace foods that are scarce with foods that are plentiful. This has also meant that the diet is cheaper, since the carbohydrate foods in general are cheaper than the protein and fat foods which they have replaced. Finally, a group of patients, including some severe cases, have agreed to forgo the extra rations allowed to them by the Government, and they have remained just as stable and well without them. We believe, therefore, that even if the food rations have to be still further reduced and the diet of diabetic patients is affected they could be maintained in good health on the new diet.

Summary

A diabetic diet is described in which the total calorie value is kept constant but an unlimited variation in the proportion of carbohydrate, protein, and fat is permitted.

The effect of this diet has been examined after one year's trial on a large series of cases and found to be satisfactory.

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THE ACTION OF RADIANT-HEAT CRADLES

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The Physical Action of Cradles

The cradles used were those issued by the Ministry of Home Security, consisting of a sheet of polished metal bent in the shape of a horseshoe, and fitted with 12 carbon filament bulbs of 230 volts and 16 c.p. (about 65 watts) controlled by two switches. Each switch controls 6 bulbs and is so arranged that 2, 4, or 6 bulbs can be switched on. The object of the cradle is to supply heat to patients, and our primary aim was to investigate how this end was achieved by this type of cradle. It was also hoped that an analysis of the factors involved might suggest improvements in the apparatus.

The usual method of employing such cradles is to place the patient inside, covered with a blanket, and to drape another blanket over the whole cradle so as to retain the heat. The radiation emitted by the bulbs consists almost exclusively of infra-red rays of long wave-length, the remaining small percentage being emitted as visible light and short-wave infra-red rays. This radiation either falls directly on the blanket-covered patient or is reflected without change of constitution from the polished surface of the metal background. A certain amount is absorbed by the background, and the latter is gradually raised in temperature until it forms a source of long-wave infra-red radiation on its own.

Before reaching the patient, however, the radiation encounters the blanket, which becomes warmed on its upper surface and radiates heat as long infra-red rays on its own account. A certain amount passes through the blanket to the patient; but since the blanket is a good insulator, this is a very inefficient method of transferring heat. The energy which reaches the patient is thus much reduced in amount, but has been converted by the action of the blanket into very long infra-red rays. Some such convertor mechanism appears to be necessary; for, as we shall see, when a patient is placed in the unshielded cradle without the protection of a blanket he soon begins to suffer from burns. A mode of conversion was therefore adopted which involved a negligible loss of energy.

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The metal background of the cradle was blackened† and the bulbs were covered with strips of thin metal which cut off the direct radiation completely, but which rapidly became hot and acted as a source of long infra-red radiation like the cradle background (Fig. 1). The blackening of the background ensured 100% absorp-

FIG. 1.—Modified cradle.

FIG. 2.—Skin thermometer.

tion of the direct radiation incident upon it from the bulbs, so that in this "shielded" cradle the heat transmitted to the patient is furnished only by the thermal radiation of the cradle background and the shielding strips.

In order to measure the radiation a small blackened square of copper was used, the temperature of which was measured by means of a thermo-junction fixed to its back. As this is heated by the incident radiation, which it absorbs completely, the radiation emitted from its surface is also increased, until after a few seconds the receiver is in equilibrium with its surroundings and emits as much as it absorbs. The temperature of the receiver is then the same as the effective temperature of the radiation field, provided that no heat conduction takes place.

For the physiological part of the investigation a suitable skin-temperature thermometer had to be devised. The form adopted (Fig. 2) consisted of a small grid about 4 cm. by 2 cm. of fine copper mesh carrying a thermo-junction on the side in contact with the skin, the whole being protected by a thin coat of shellac varnish. The junction thus gave a mean value of the skin temperature over the whole area covered by the mesh because of the good heat conductivity of the latter. The skin was exposed to the air and was free to sweat, while the area obstructed by the wires of the mesh was sufficiently small not to interfere with the full access of the radiation to the skin. Three such instruments, of mesh sizes from 1 mm. to 2 mm., were found to give consistent readings over a wide range of radiation temperatures and air temperatures.

Experiments were carried out with a blanket over the cradle and all 12 bulbs switched on. The radiation meter was placed a few centimetres above bed level in the centre of the area covered by the cradle. Fig. 3 shows graphs of the observed temperatures of the receiver plotted against time. The receiver is affected by radiation from the bulbs and from the metal background, as well as by con-

FIG. 3.—Radiation from shielded and unshielded cradle. For details see text.

duction through the air. The room temperature is represented by 0A and the cradle is switched on at A. In the unshielded cradle the curve ABC is followed. At C the bulbs are switched off and the temperature immediately falls to F and dies away along FG as the cradle begins to cool.

In the shielded cradle, in which direct radiation from the bulbs is absent, the curve AFG is followed. Thus the contribution AB must be due to the direct radiation from the bulbs. This component of the radiation remains constant in time, as is evident from the fact that when the bulbs are switched off at C the drop in radiation recorded, CF, equals the initial rise, AB. The curves AF and BC are almost identical,‡ and this implies that the amount of heat supplied by the bulbs to the cradle background is the same whether

† A thin coat of any flat black-out paint, not water-soluble, is suitable.

‡ This is strictly true in an energy-time diagram, and is almost exact in our temperature-time diagram because of the very small range of temperature involved.