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Nutrient Intake of Subjects on Low Carbohydrate Diet Used in Treatment of Obesity[1]

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IN BRITAIN many people have found that the low carbohydrate diet is a satisfactory way of treating overweight; it is the choice of a majority of British physicians (1). The essential feature is the restriction of the daily intake of carbohydrate to some 50 or 60 g, but no conscious restriction of protein or fat. The result, it is claimed, is a diet that has several advantages over other weight-reducing diets, a major advantage being its high nutritional value (2).

In the United States of America, this diet is condemned by most authoritative medical and nutritional opinion (3), although, as in Britain, it is widely used by the lay public. One of the reasons for this condemnation is the belief that the diet is nutritionally not sound.

A considerable amount of opinion has been expressed, both in support and in criticism of the low carbohydrate diet, but most of it has been on the theoretical assumption of what is consumed by people on such a regimen. There has been only one reported study of what people do eat when following the low carbohydrate diet (4). This consisted, however, of an assessment of only the protein, carbohydrate, fat, and consequently the calories, that were taken before and during the adoption of the low carbohydrate diet by six subjects. We now have repeated these observations with 11 more subjects and have assessed the intake of a number of vitamins and mineral elements, as well as the protein, carbohydrate, and fat. Five of our subjects were nutrition students; the other six, as well as the six subjects in the previous study, had no special knowledge of the subject.

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SUBJECTS

We assessed the food intake of 11 apparently normal subjects while they consumed their usual diet and later while they were on a low carbohydrate diet. The subjects were three men and eight women, aged from 21 to 51 years. They were instructed how to keep intake records of all food and liquids consumed for the 2-week periods on each diet. The instructions relating to the low carbohydrate diet were identical to those given to patients attending a hospital overweight clinic under our supervision. Essentially, the subjects were asked to take between 10 and 20 oz milk daily (about 300–600 ml), and as much meat, fish, eggs, cheese, butter, margarine, cream, and leafy vegetables as they wished. The amount of carbohydrate in other food was listed in "units" with each unit consisting of 5 g carbohydrate; the subjects were told to limit these foods to not more than 10 units (or 50 g) carbohydrate daily. The intake of calories and nutrients other than vitamins was calculated from the food records using the tables of McCance and Widdowson (5). The intake of vitamins was calculated from tables compiled by Pellett and Wheeler (6).

RESULTS

In conformity with our experience with this diet during the last 15 years, none of

TABLE I

Change in average daily intake of calories and calorigenic constituents of 11 subjects on a low carbohydrate diet

	Normal diet	Low carbohydrate diet	Difference	P
Calories	2,330 ± 144 (2,340)	1,560 ± 64 (1,390)	−770 (−950)	<0.001
Protein, g	84 ± 7.0 (77)	83 ± 3.8 (80)	−1 (+3)	NS
Fat, g	124 ± 9.8 (122)	105 ± 5.1 (99)	−19 (−23)	NS
Carbohydrate, g	216 ± 10.9 (206)	67 ± 13.0 (65)	−149 (−141)	<0.0001

Figures in parentheses are the results found by Yudkin and Carey (4).

TABLE II

Changes in intake of vitamins A, D, and C on the low carbohydrate diet

Vitamin	Normal diet	Low carbohydrate diet
Vitamin A, mg	2.06	2.07
Carotene, mg (vitamin A equivalent)	1.00	1.03
Vitamin D, IU	200	310[a]
Ascorbic acid, mg	70	75

[a] Significant change ($P < 0.01$).

TABLE III

Changes in intake of B vitamins on the low carbohydrate diet

Vitamin	Normal diet	Low-carbohydrate diet	Number showing significant changes	
			−	+
Thiamin, mg	1.13	0.93	3	0
Per 1,000 kcal	0.49	0.60[a]	0	2
Riboflavin, mg	1.66	1.75	0	1
Per 1,000 kcal	0.71	1.12[b]	0	8
Nicotinic acid, mg	13.1	11.0	2	1
Per 1,000 kcal	5.61	7.04[b]	0	4

Significant change: [a] $P < 0.005$. [b] $P < 0.001$.

our subjects complained of hunger or any other ill effects; on the other hand, several volunteered statements to the effect that they had an increased feeling of well-being and decreased lassitude. The average intake of calories and of protein, fat, and carbohydrate for the 11 subjects is shown in Table I, from which it can also be seen that the values were remarkably similar to those obtained for the six subjects of the previous study. There was no difference in intake between the nutrition students and the others.

The average intake of vitamin A, carotene, and vitamin C was not significantly changed by the low carbohydrate diet (Table II). The average intake of vitamin D was increased by about 50%, but since the amount of this vitamin varies considerably in the diet—more than that of any other nutrient (7)—we do not attach much importance to this difference. When we looked for significant changes for the individual subjects, we found that vitamin A intake fell in 1 subject and rose in another; vitamin D intake fell in 2 subjects and rose in 5; and ascorbic acid intake fell in 1 subject and rose in 10.

We have expressed the intake of thiamin, riboflavin, and nicotinic acid both in absolute terms and in relation to calorie intake, since it is likely that the requirements of these nutrients are related to the utilization of calories (Table III). The average figures show a significant rise in intake of all three vitamins in relation to calories, but no change in absolute

amounts. The low carbohydrate diet reduced the absolute intake of thiamin in three subjects and of nicotinic acid in two subjects, but increased riboflavin in one subject and nicotinic acid in another. In relation to calories, however, no subjects had a reduced intake of any of these three vitamins, and several had an increased intake.

There was a fall in calcium intake in four of the subjects (Table IV). Total iron fell in one subject and increased in another. However, because the absorption of iron from animal foods is, in general, much better than from vegetable foods—especially cereals—it is relevant to point out that the intake of "animal" iron increased in three subjects and was reduced in none of them.

DISCUSSION

The most detailed criticism of the low carbohydrate diet is that of Hodges and Krehl (8), which claims that the diet is likely to produce not only dietary deficiency but a number of other pathological conditions. The deficiencies that are enumerated are of calcium, thiamin, riboflavin, folic acid, and ascorbic acid. The other hazards include dehydration, electrolyte imbalance, ketosis, hyperuricemia, fatigue, and increased serum lipids.

That one or two subjects showed a fall in intake in one or two nutrients is not surprising when one considers that the average total intake, measured as calories, fell on the average by one-third and in two subjects by more than one-half. The relevant question is whether an alternative method that restricts calories to the same extent as the low carbohydrate diet would result in a better intake of the nutrients.

Most of the critics of the low carbohydrate diet recommend an overall restriction of food, rather than a specific restriction of the carbohydrate-rich foods. The result, of course, would be that the nutrients would be reduced exactly in proportion to the calories. We could compare, therefore, the nutrient intake of our 11 subjects when they adopted the low carbohydrate diet with the nutrient intake they would have had from diets restricted in all foods so as to give the same calorie intake.

We may take *subject 8* as an example, since his intake of calories on the low carbohydrate diet was 65% that of his normal diet; this is similar to the mean value of 67% for the group. Had this subject reduced his calorie intake to 65% of normal by reducing his food consumption uniformly, he would clearly have been taking 65% of his usual protein intake, 65% of his usual vitamin A and so on. In absolute amounts, thiamin, riboflavin, and nicotinic acid would have been reduced similarly; expressed in terms of calorie intake, however, the values would have remained the same, i.e., 100% of normal.

In fact, *subject 8* took 90% of his usual protein intake, 112% vitamin A, 112% vitamin D, 138% ascorbic acid, 84% thiamin, 101% riboflavin, 71% nicotinic acid, 61% calcium, and 87% iron. In relation to calories, the B vitamins were 127, 167, and 110% of his normal intake. In all but one of these nutrients, therefore, the intake was better on the low carbohydrate

TABLE IV

Changes in intake of mineral elements on the low carbohydrate diet

Mineral element	Normal diet	Low carbohydrate diet	Number showing significant changes	
			−	+
Calcium, mg	1,070	980	4	0
Total iron, mg	12.8	11.7	1	1
Animal	6.8	8.6[a]	0	3
Cereal	2.8	1.3[a]	8	0
Vegetable	3.2	1.9[a]	5	0

[a] Significant change: $P < 0.05$.

diet than it would have been if the subject had restricted his food intake generally to the same 65% of normal. The exception was calcium, which was lowered by an insignificant amount, from 65 to 61% of normal.

We made these calculations for all 11 subjects and for the nine nutrients, protein, vitamin A, vitamin D, vitamin C, thiamin, riboflavin, nicotinic acid, calcium, and iron—99 items altogether. We then found that the low carbohydrate diet led to a lower intake than would have occurred by an equivalent overall reduction of calories in 12 items and a higher intake in the remaining 87 items. Moreover, the differences in some of the 12 items were so small as to be of little or no nutritional significance. For example, one item refers to the vitamin A intake of one subject that was reduced to 1.18 mg daily on the low carbohydrate diet but would have been 1.22 mg if the subject had uniformly reduced his total diet to give the same number of calories. A second example, to which we have already referred, was the reduction of calcium intake to 61% of normal where it otherwise would have been reduced to 65%.

An assessment of the nutrient value of diets is not complete and realistic unless an account is taken of the availability of the nutrients. Although we do not yet know all the factors that affect nutritional availability and, in particular, we do not know their quantitative effect, we can, nevertheless, add a little to our comments on the nutrient value of the low carbohydrate diet in respect to nicotinic acid and to iron.

A large part of the nicotinic acid in the subjects' ordinary diets came from bread and other cereal products, but in their low carbohydrate diet it came mostly from meat and other animal products. It appears that this vitamin is almost entirely unavailable from cereals, so that, in fact, substitution of the normal diet by the low carbohydrate diet resulted in a better nicotinic acid supply than appears from the figures in Table III.

Iron, too, is said to be poorly absorbed from cereals and vegetables, whereas it is well absorbed from animal foods. Therefore, we have given in Table IV the values of iron intake from both these sources. The iron supplied to our subjects was not simply somewhat better in 10 out of our 11 subjects, but was much better in all of them. Thus, the subject whose average daily intake of total iron was reduced on the low carbohydrate diet from 13.2 to 10.7 mg had, in fact, an increase in iron from animal food from 6.2 to 9.7 mg.

Because of the paucity of information of the amounts of folic acid in food and especially the availability of various forms of the vitamin, we have not attempted to assess the intake of this nutrient. A very approximate assessment, however, may be made from the knowledge of the intake of carotene, since this is largely derived from leafy vegetables and these, in turn, are good sources of folic acid. The average carotene content of the low carbohydrate diet was almost precisely the same as that of the normal diet in spite of the reduction of calories; in terms of reduced calories, only one subject showed a lower intake of carotene on the low carbohydrate diet than he would have had from a generally reduced diet of the same calorie content—4,600 IU instead of 5,400 IU. We have no reason to suppose, therefore, that the low carbohydrate diet is likely to be deficient in folic acid.

The view that the low carbohydrate diet has other hazards, as well as those of nutritional deficiency, derives chiefly from two misconceptions. One is that the low carbohydrate diet is high in protein and fat; the other is from results of experiments with diets that were virtually carbohydrate free.

The paper of Hodges and Krehl (8) states "Low carbohydrate diets are una-

voidably high in both protein and saturated fats." In absolute terms, this is not true. We have shown both in the present and earlier papers that the diet has almost the same amounts of protein and fat as ordinary free-choice diets. It is of course true that, in relative terms, when the absolute amount of carbohydrate and calories is decreased, the proportion of calories coming from fat and protein must be increased. We know of no evidence that an amount of fat and protein considered harmless in a diet high in carbohydrate becomes hazardous when it is given in a diet low in carbohydrate.

Effects such as fatigue, sodium loss, and ketosis have been reported by Bloom and Azar (9) as occurring on a diet that is virtually free from carbohydrate, but Hodges and Krehl (8) quote them as if they were referring to diets low in carbohydrate. In fact, Bloom and Azar were able to correct the effects of their carbohydrate-free diet entirely by the addition of 75 g carbohydrate daily. Moreover, if we use the recognized formula that states that ketosis will occur when fat intake exceeds twice the carbohydrate intake plus half the protein intake, we can say that each of our subjects took an amount of carbohydrate that would comfortably prevent ketosis.

We conclude, therefore, that the low carbohydrate diet presents no health hazard, either generally or in regard to its nutritional value. The nutrient content is appreciably higher than could be achieved by a diet in which the same caloric reduction was effected by a general restriction in all foods.

SUMMARY

The diets of 11 men and women were assessed for 2 weeks before, and for 2 weeks after, they had adopted the low carbohydrate diet that is often used in the treatment of obesity. The nutrient value of the low carbohydrate diets was in general appreciably higher than would have been achieved if the subjects had reduced their calorie intake to the same degree by an overall reduction in their normal diets. The amounts of protein, fat, and carbohydrate in the low carbohydrate diet gave no support to the contention that it is hazardous in regard to dehydration, ketosis, hyperuricemia, or hyperlipidemia.

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