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Acknowledgment

The author would like to thank the reviewers and the editors, especially Melinda Downie Maryniuk, MEd, RD, CDE, FADA, for their helpful feedback on this article. The author would also like to thank Geoffrey Greene, PhD, RD, Julie Wagner, PhD, and Keith Campbell, RPh, for their feedback on this article.

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In Brief

People with diabetes are frequently given advice about protein that has no scientific basis. In addition, although weight is lost when individuals follow a low-carbohydrate, high-protein diet, there is no evidence that such diets are followed long-term or that there is less recidivism than with other low-calorie diets. People with type 1 or type 2 diabetes who are in poor metabolic control may have increased protein requirements. However, the usual amount of protein consumed by people with diabetes adequately compensates for the increased protein catabolism. People with diabetes need adequate and accurate information about protein on which to base their food decisions.

Protein Controversies in Diabetes

Marion J. Franz, MS, RD, LD, CDE

In the United States, ~16% of the average adult consumption of calories is from protein, and this has varied little from 1909 to the present.¹ Protein intake is also fairly consistent across all ages from infancy to older age.

A daily intake of 2,500 calories contributes ~100 g of protein—about twice what is needed to replace protein lost on a daily basis. Excess amino acids must be converted into other storage products or oxidized as fuel. Therefore, in theory, the excess ingested protein could, through the process of gluconeogenesis, produce glucose. This would mean that 100 g of protein could produce ~50 g of glucose. This has been the basis of the statement that if about half of ingested protein is converted to glucose, protein will have one-half the effect of carbohydrate on blood glucose levels.

However, this belief has been challenged.²⁻⁴

Protein controversies exist either because research has not provided conclusive answers or because professionals are not aware of the research. This article will review available research on common advice given to people with diabetes in regard to protein, the high-protein and low-carbohydrate diets, and protein requirements for people with type 1 diabetes or type 2 diabetes.

Common Advice for Protein Given to Patients with Diabetes

The following statements are not based on scientific evidence yet are often given as advice to people with diabetes.

- “Proteins” are foods like meat, cheese, and peanut butter.

- Between 50–60% of protein becomes glucose and enters the bloodstream about 3–4 hours after it's eaten.
- Don't eat fruit, fruit juice, or a "sweet" (often called fast-acting carbohydrates) for a snack without also eating protein. The protein will slow the absorption of carbohydrate.
- Bedtime snacks should always contain protein. The protein will be converted to blood glucose more slowly than carbohydrates and will keep blood glucose levels from dropping too low during the night.
- Treat an insulin reaction with a fast-acting carbohydrate and add protein to provide a later source of blood glucose. This will prevent the blood glucose from dropping too low again.
- Eating too much protein can damage the kidneys.

This article will show how these statements are often misleading and what limited evidence is available regarding these recommendations.

What are "protein" foods?

Food choices that many patients make when given advice to eat protein are usually a meat or a meat substitute, such as cheese or peanut butter. Some may also think of milk as a protein. Health professionals often call these foods "protein." But are they really protein? Certainly, they all contain protein. But most foods that contain protein also contain fat, and a few also contain carbohydrate. As illustrated in Tables 1 and 2, very few foods are only protein. Perhaps health professionals should call these foods

"meat or meat substitutes" or "protein plus fat" instead of "protein."

Does 50–60% of protein become glucose and enter the bloodstream in 3–4 hours?

Gannon and Nuttall⁴ report that in 1915, Janney calculated that ~3.5 g glucose could be produced for every gram of nitrogen excreted in the urine as the result of a beef protein meal. Beef protein is 16% nitrogen; thus, 1 g of nitrogen is excreted for every 6.25 g protein. Theoretically, then, 56% of ingested beef protein, by weight, can be converted to glucose. However, this was only a theoretical calculation. Gannon and Nuttall point out that, shortly after that calculation was reported, a number of researchers showed that the ingestion of protein by subjects with and without diabetes did not result in an increase in blood glucose levels.

As an example, as early as 1936, Conn and Newburgh⁵ reported no effect on blood glucose levels after a meal containing a large amount of protein in the form of lean beef. Fifteen subjects with diabetes and three control subjects were fed breakfasts of glucose or carbohydrate or protein foods calculated to yield equal amounts of glucose (2 g protein/kg compared to 1 g carbohydrate/kg). The blood glucose response after carbohydrate or glucose was as expected. However, there was no increase in blood glucose levels after the protein meal even though there was a consistent rise in blood urea nitrogen indicating protein utilization. The finding that protein did not raise blood glucose levels seems to have been lost or misinterpreted over the years.

More recently, data from Nuttall et al.^{6,9} also indicate that peripheral glucose concentration does not increase after protein ingestion in subjects with and without diabetes.

Nuttall et al.¹⁰ gave nine subjects with mild type 2 diabetes 50 g protein, 50 g glucose, or 50 g protein and 50 g glucose and determined the plasma glucose and insulin responses over the next 5 hours. The glucose response to glucose was as expected, but the glucose response to protein remained stable for 2 hours and then began to decline. When protein and glucose were combined, the peak response was similar to that of glucose alone. However, during the late postprandial period, the glucose response was reduced by 34%. The insulin responses for protein and glucose were similar, but when combined the insulin response was nearly doubled. The glucose decrease when protein and glucose were combined was attributed to the increased insulin response to the combination. See Figure 1.

Gannon et al.¹¹ reported on the glucose appearance rate over 8 hours following the ingestion of 50 g protein in the form of very lean beef compared to water in subjects with type 2 diabetes. After water alone, the plasma glucose concentration decreased from 6.7 mmol/l (120 mg/dl) to 5.4 mmol/l (98 mg/dl). After 50 g of protein, the glucose concentration at 1 hour increased by 0.1 mmol/L (3 mg/dl) and then decreased similarly to water. The ingested protein resulted in only ~2 g glucose being produced and released into the circulation. The fate of the remaining absorbed amino acids is unknown. Plasma insulin

Table 1. Protein in Foods

	Calories from protein	Calories from fat	Calories from carbohydrate
Very lean meats (shrimp, 3 oz)	71	8	0
Lean meats (chicken, fish, lean beef, veal, ham, 3.5 oz)	124	41	0
Medium-fat meats (extra-lean ground beef, beef or pork roasts, pork chops, 3.5 oz)	102	147	0
High-fat meats (processed meats, cheese, 1 oz)	12	74	2.5
2% milk, 1 cup	32	42	48
Lentils, 1 cup	72	7.2	160

Table 2. Protein and Fat in Meat and Meat Substitutes

	Calories from protein	Calories from fat
Low fat meat, 1 oz	28	27
Beef jerky, 1 oz	64	50
Beef bologna, 1 oz slice	12	75
Cheese, 1 oz	28	85
Nuts (almonds), 1 oz	22	131
Peanut butter, 2 Tbsp	32	144
Hot dog, 1	28	147

changed little after water, but after protein there was a threefold increase in insulin and a 50% increase in plasma glucagon.

This raises the question of why, if gluconeogenesis from protein occurs, does the glucose produced not appear in the general circulation? Several theories have been suggested. The first is that considerably less than the theoretical amount of glucose (50–60%) produced from protein actually is produced and enters the general circulation, and the small amount of glucose released is matched by a corresponding increase in glucose use, if adequate insulin is available.⁴ Another theory suggests that the process of gluconeogenesis from protein occurs during a 24-hour period, and the slowly and evenly produced glucose can be disposed of over a long period of time.⁵ It is also speculated that the insulin stimulated by dietary protein causes the glucose formed to be rapidly stored as glycogen in the liver and in skeletal

muscles. This glucose can then be released when insulin levels are low or glucagon levels are elevated, and the body does not identify if the glucose is from protein or carbohydrate.

To understand this process of gluconeogenesis and the question of why protein does not affect blood glucose levels, it is helpful to briefly review the metabolism of dietary proteins. The majority of protein is digested, and the amino acids not used for gut fuel are metabolized in the intestinal mucosal cells and transported by the portal vein to the liver for protein synthesis or gluconeogenesis.¹² In the liver, nonessential amino acids are largely deaminated, and the amino group (nitrogen) removed is converted into urea for excretion in the urine.¹³ It has been shown that in subjects without and with mild type 2 diabetes, ~50–70% of a 50-g protein meal is accounted for over an 8-hour period by deamination in the liver and intestine and synthesis to urea.¹⁴ It has

been assumed that the remaining carbon skeletons from the nonessential amino acids are available for glucose synthesis, which would then enter into the general circulation.

The essential amino acids pass through the liver into the general circulation, where they may be removed and used for new protein synthesis or, alternatively, for skeletal muscle fuel. Circulating amino acids stimulate insulin and glucagon secretion. The amino acids that stimulate glucagon are different from those that stimulate insulin secretion.^{15–17}

To add to the confusion, the effect of protein on glucose appearance is influenced by insulin availability. With insulin deficiency, the oxidation of branched chain amino acids in muscle and uptake of alanine (the principle glycogenic amino acid) by the liver is accelerated, resulting in increased gluconeogenesis and augmented protein catabolism.¹⁸ The accompanying rise in glucose levels is

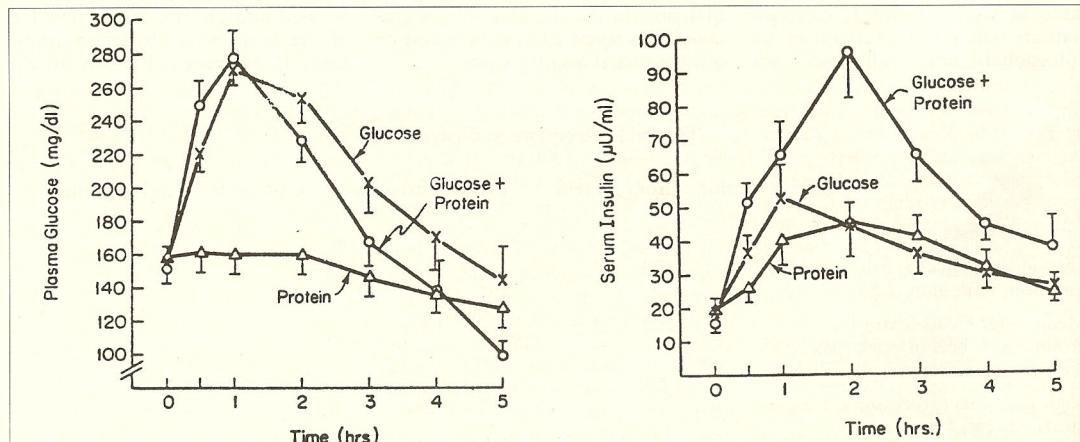


Figure 1. Plasma glucose and serum insulin responses to ingestion of 50 g glucose, 50 g protein, or a combination of 50 g glucose + 50 g protein. Reprinted with permission from reference 10.

most likely due to an increased conversion of ingested protein into glucose and to a decreased glucose removal rate. In subjects with diabetes who had insulin withheld for 24 hours, there was a three- to fourfold increase in liver glucose output after protein ingestion.¹⁹ However, in the presence of insulin, alanine uptake by the liver is virtually zero,²⁰ and hepatic glucose production falls by 85%.²¹ Indirectly then, insulin could reduce gluconeogenesis in the liver by decreasing the amino acid substrate supply. Insulin also inhibits the degradation of body proteins and lowers the circulating concentration of many amino acids.²²

The net effect on glucose output by the liver depends on the ratio of insulin to glucagon. In people with type 1 or type 2 diabetes, the glucagon response to protein is considerably greater than in people without diabetes.⁴ Glucagon stimulates an increase in hepatic glucose production due to an increase in glycogenolysis and an increase in gluconeogenesis. Glucagon antagonizes the effect of insulin in the liver. However, it does not antagonize the insulin-stimulated uptake of glucose in muscle or the insulin-mediated decrease in release of non-esterified fatty acids from fat cells.⁴

Therefore, the process of gluconeogenesis is affected by substrate supply and level of glycemic control. However, in people with well-controlled diabetes, minimal amounts of hepatic glucose are released into the general circulation after the ingestion of protein.

Does protein slow the absorption of carbohydrate?

In the study by Nuttall et al.,¹⁰ when protein and glucose were combined, the peak response was similar to the peak response of glucose alone. That is, adding protein to carbohydrate did not slow the absorption or peak of the glucose response. (Figure 1).

Incidentally, what is a "fast-acting" carbohydrate? Previously, it was assumed that fast-acting carbohydrates were sugars or juices. It is now known that this is not true, and if there were a fast-acting carbohydrate, it would probably be a starch.²³ "Fast-acting carbohydrate" is a term we need to eliminate from our diabetes vocabulary.

The effect of adding protein (25 g) or adding fat (5 or 10 g) to breakfasts

containing 60 g carbohydrate in 24 subjects with type 2 diabetes was also studied by Nordt et al.²⁴ Glucose concentrations were similar after the three meals, but after the protein-enriched meal, the postprandial insulin and glucagon responses were significantly increased. Neither varying the ratio of fat to protein nor increasing the amount of fat affected postprandial glucose values. The late reduction in postprandial glucose observed by Nuttall et al.¹⁰ with the addition of protein was not seen in this study. This may be due to the fact that in this study more normal amounts of protein were added.

How adding large amounts of protein or fat to a standard lunch would affect postmeal glucose responses and insulin needs in subjects with type 1 diabetes was studied by Peters and Davidson.²⁵ In 12 individuals who by the use of a biostator were euglycemic, a standard lunch (450 kcal) was compared to protein-added (200 kcal) or a fat-added (200 kcal) lunch. After the fat-added lunch (2 Tbsp margarine), the peak glucose response was delayed, but the total glucose response was unchanged. After the protein-added lunch (7 oz turkey), the early glucose response was similar to the standard lunch, but late glucose response (2–5 hours) was slightly increased, and the late insulin requirement was greater by 3–4 U. This late insulin requirement (2–5 hours) was statistically significant, although the total insulin requirement over the 5 hours was not.

Adding protein did not delay the peak glucose response, but whether the addition of protein to a meal or snack prevents late-onset hypoglycemia cannot be answered by this study. The study ended at 5 hours, at which time glucose levels were similar

after all three meals. (Figure 2.)

Thus, the carbohydrate content of the meal is the main determinant of the peak glucose response.^{26,27} Although this may vary depending on the glycemic response to the carbohydrate, it appears not to be affected by the protein content. Fat delays the peak but not the total glucose response.^{25,28} However, patients often report that when they eat large amounts of certain foods, such as pizza, meat, or fat, their blood glucose responses are elevated even if they keep their carbohydrate consistent.^{29,30} The reason remains a mystery, but this does mean that if patients have documented this response to certain foods, they will probably need to adjust their premeal short- or rapid-acting insulin or eat smaller servings of these foods.

Is it important to have protein for a bedtime snack or before exercise?

First, we should consider the logic of recommending the addition of 1–2 oz. of protein to prevent hypoglycemia. Even if 50% of the protein were converted to glucose and entered into the circulation, this would only be a total of 3.5–7 g of glucose. It is unlikely that this amount of glucose would have much effect on increasing blood glucose levels. The mechanism would have to be due to protein's effect on glucagon (or on other counterregulatory hormones). However, the effects of glucagon are reported to be short-lived and transient.^{31,32}

The recommendation to add 1 or 2 oz of protein to an evening snack to prevent late-onset hypoglycemia was studied by Hess and Beebe.³³ In 15 well-controlled subjects with type 1 diabetes, two bedtime snacks, 30 g carbohydrate or 30 g carbohydrate plus 14 g protein, were consumed on

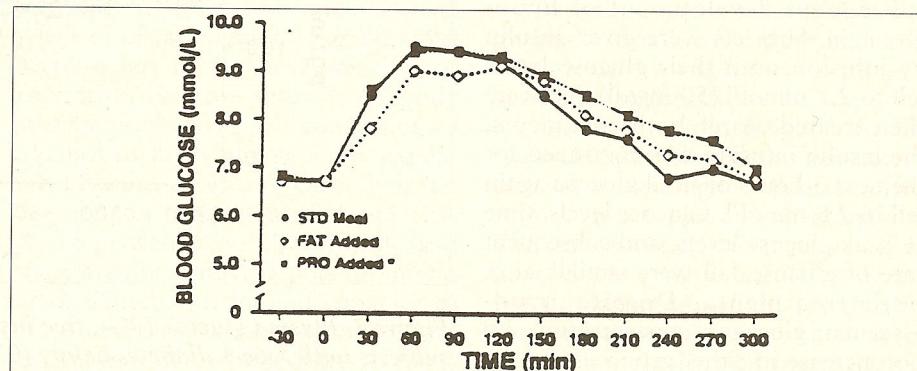


Figure 2. Blood glucose response for a standard (STD) meal, protein-added (PRO) meal, and fat-added meal. Reprinted with permission from reference 25.

three separate occasions, and blood glucose was compared at 1, 2, and 3 hours postprandial and at fasting. Blood glucose values before the bedtime snack (132 vs. 120 mg/dl) and 1 hour and 2 hours after the snacks were similar, but blood glucose values at 3 hours postprandial and at fasting were significantly higher after the protein-containing snack (144 vs. 164 mg/dl 3 hours postprandial, and 112 vs. 143 mg/dl fasting, respectively).

There were no significant differences in hypoglycemic incidents, so it is uncertain whether adding protein to a 30-g carbohydrate snack was necessary or whether it just added unneeded calories. However, if overnight hypoglycemia is a problem that cannot be corrected by insulin adjustments, rather than add extra carbohydrate to the bedtime snack, protein could be tried. Furthermore, if individuals were still hungry after the 30-g carbohydrate snack, adding extra protein might be better than adding extra carbohydrate.

There is also no evidence to suggest that adding protein to a snack before (or after) exercise prevents hypoglycemia any better than just a carbohydrate snack. Nathan et al.³⁴ reported that in intensively treated individuals with type 1 diabetes, a 13-g carbohydrate snack before exercise of short duration (<45 min) was enough to prevent post-exercise hypoglycemia.

Does adding protein to the treatment of hypoglycemia prevent late-onset hypoglycemia?

In a small study (six subjects with type 1 diabetes), Gray et al.³⁵ reported on the rate of restoration of euglycemia after treatment of hypoglycemia with either identical amounts of carbohydrate (15 g) or carbohydrate supplemented with protein (14 g) and the subsequent development of hypoglycemia. Subjects were given insulin by infusion until their glucose levels fell to 2.8 mmol/l (50 mg/dl) and were then treated. After both treatments, the insulin infusion was continued for the next 3 hours or until glucose again fell to 2.8 mmol/l. Glucose levels, time to peak glucose levels, and subsequent rate of glucose fall were similar after both treatments. Despite hypoglycemia, glucagon concentration did not increase in either group until food was ingested. At that point, there was a transient increase in glucagon in the group treated with carbohydrate plus protein with no effect on glucose lev-

els (Figure 3.). The researchers concluded that adding protein to the treatment of hypoglycemia merely adds unneeded calories.

Does eating a high-protein diet cause renal disease?

Despite the widespread belief that protein ingestion can influence the development of renal disease, dietary intake of protein is reported to be similar in patients with or without nephropathy. Nyberg et al.³⁶ investigated protein intake in three groups: 1) patients who had diabetes 30 years or more without nephropathy; 2) patients with nephropathy but stable glomerular filtration rates; and 3) patients with progressive nephropathy and declining glomerular filtration rates. In all three groups, average protein intake was >80 g/day (~16–17% of daily calories), with no relationship between the amount of protein ingested and the progression of nephropathy.

Watts et al.³⁷ investigated dietary

protein in patients with type 1 diabetes with and without microalbuminuria. Dietary protein intake was similar in both groups. Ekberg et al.³⁸ also found no support for a relationship between high protein intake and glomerular hyperfiltration in insulin-treated patients. In tobacco users with hyperfiltration, a positive relationship was found between urinary albumin excretion and protein intake, but this was not found in non-users of tobacco. Jameel et al.³⁹ reported on dietary protein intake and clinical proteinuria in patients with type 2 diabetes. Again, protein intake was similar, with no correlation between protein intake and clinical proteinuria. In all of the above studies, protein intake was in the range of usual dietary intake and rarely exceeded 20% of the calories.

In a cross-sectional, clinic-based study (EURODIAB IDDM Complications Study) of more than 2,500 people with type 1 diabetes, individuals who reported protein consumption of <20% of total calories had averag-

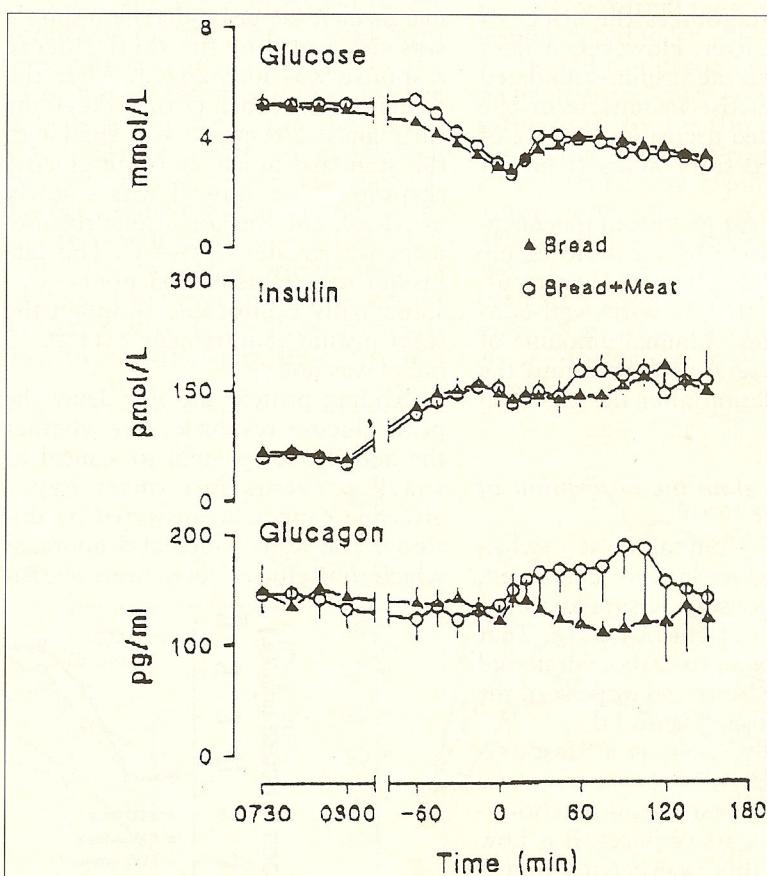


Figure 3. Plasma glucose (PG), free insulin, and glucagon concentrations in subjects with type 1 diabetes before (0730–0800 h) and during (60–180 min) test insulin infusion. Time zero is the point at which PG levels first reached 50 mg/dl and subjects ingested either bread alone or bread plus meat. The test insulin infusion was continued for the next 3 h (0–180 min) or until PG fell again to 50 mg/dl. Reprinted with permission from reference 35.

albumin excretion rates (AERs) below 20 mg/min. However, in those in whom protein intake was >20% (22% of patients), average AERs increased and were in the microalbuminuric range (>20 mg/min). Of the patients with macroalbuminuria, 32% consumed >20% of protein, while this percentage was 23% for the microalbuminuric and 20% for the normoalbuminuric individuals with type 1 diabetes. Trends reached statistical significance for total protein and animal protein, while no association was seen for vegetable protein. This trend was particularly pronounced in patients with hypertension and/or elevated HbA_{1c} values. These findings support the recommendation for people with diabetes not to consume protein intakes >20% of total calories.⁴⁰

In an interesting study, excess microalbuminuria was related to saturated fat intake and not to protein. In a cross-sectional, population-based study of Tasmanian adults with type 1 diabetes with microalbuminuria, on at least two or three occasions, excess microalbuminuria was associated with relative high intakes of saturated fat and a decreased prevalence with relative high intakes of protein.⁴¹

High-Protein, Low-Carbohydrate Diets

Weight loss and improved blood glucose control are claims being made for high-protein, low-carbohydrate diets. The advantages of the high-protein, low-carbohydrate approach are that diets that eliminate a whole category of nutrients, in this case carbohydrates, are lower in calories and so result in weight loss. With a high protein intake and strict limitation of carbohydrate, water stored with glycogen (carbohydrate) is released. This rapid loss of fluid is an initial boon to dieters looking for fast results. Unfortunately, it isn't stored fat that is being lost. Fasting ketosis, which results in loss of appetite, may also develop. Furthermore, few people can eat endless amounts of animal protein and fat for weeks on end, and so they eat less and less. The good news is that, with a high-protein diet, weight is lost, insulin needs drop, and blood glucose and sometimes even lipid levels often improve. It works, at least temporarily.

Although the authors of the popular books all take a slightly different approach, the basic premises are fairly similar. Eating a high-carbohydrate

diet makes people "fat" because carbohydrates increase blood glucose levels, causing a greater release of insulin, and higher insulin levels cause carbohydrate to be stored easily as fat. Eating a high-protein diet leads to weight loss, decreased insulin levels, and improved glycemia. However, neither this nor the claim to "cure" insulin resistance—the oversecretion of insulin which they say causes carbohydrate to be stored as fat—with a low-carbohydrate, high-protein diet is supported by scientific evidence.

Nor is there good evidence that insulin resistance from eating a diet rich in starchy foods and sugar is the cause of obesity. In fact, it is obesity that causes insulin resistance, not the other way around. But regardless, increased physical activity, energy restriction and/or moderate weight loss, and controlling fat intake have been shown to improve insulin sensitivity, not changes in the protein-to-carbohydrate ratio.^{42,43}

High-protein diets claim to offer other benefits. For example, protein stimulates the release of glucagon, a hormone that raises the level of blood glucose and counteracts the actions of insulin, and eating right means balancing insulin and glucagon levels. Therefore, the argument goes, if not enough protein is eaten, too much insulin is released and not enough glucagon. It is true that the balance of insulin and glucagon release is important in the metabolism and storage of nutrients. But it is doubtful that you can change the balance by eating more protein.

Another claim is that if the right kinds of fat are eaten, individuals will not become fat. However, there appears to be a hierarchy for the autoregulation of substrate utilization and storage that is determined by storage capacity and specific fuel needs of certain tissues.⁴⁴ For example, alcohol has the highest priority for oxidation because there is no body storage pool for it, and conversion of alcohol to fat is energetically expensive. Amino acids and carbohydrates are next in the oxidative hierarchy. Body proteins are functional, and there are not storage depots for amino acids. There is a limited capacity to store carbohydrate as glycogen, and conversion of carbohydrate to fat is energetically expensive as well. In contrast, there is virtually unlimited storage capacity for fat, largely in adipose tissue, and the storage efficiency of fat

is high. Because of the oxidative priority of alcohol and protein, the body has an exceptional ability to maintain their balance across a wide range of intake of each. Carbohydrate oxidation closely matches carbohydrate intake.^{45,46} Therefore, the amount of fat oxidized or stored is the difference between total energy needs and the oxidation of the other priority fuels—alcohol, protein, and carbohydrate.

Protein, Satiety, and Weight Loss

The effects of dietary fat and carbohydrate on regulation of energy intake, weight loss, and satiety have been studied, but little research has been done related to protein. Short-term studies have suggested that protein exerts a more positive effect on satiety per calorie than both carbohydrate and fat.⁴⁷⁻⁴⁹ However, this may not translate into eating fewer calories. Stubbs et al.,⁴⁹ in a 1-day study, reported that although subjective hunger was less after a high-protein breakfast compared to a high-fat or high-carbohydrate breakfast, lunchtime intake 5 hours later and energy intake for the rest of the day were similar after all three breakfasts.

Skov et al.⁵⁰ studied the effect on weight loss in obese subjects of replacement of carbohydrate by protein in *ad libitum* fat-reduced diets. Food was supplied to the 50 subjects for 6 months and could be consumed *ad libitum*. The diets were low in fat (30% of energy) with a group randomly assigned to either a high-protein (25% protein, 45% carbohydrate) or high-carbohydrate (12% protein, 58% carbohydrate) diet. At 6 months, the high-protein group had lost 8.9 kg (20 lb) with a fat loss of 7.6 kg (17 lb) compared to the high-carbohydrate group loss of 5.1 kg (11 lb) and fat loss of 4.3 kg (9 lb).

Over the course of the study, energy intake was lower in the high-protein group by ~8,000 calories (~42 kcal/day), which probably accounted for the difference in weight loss. The researchers attributed the decrease in calories to the higher satiating effect of protein compared to carbohydrate. The real test of effectiveness would be to follow the subjects for the next 2 years to identify food choices after the completion of the study and to determine if weight lost during the study was maintained.

Aside from the problem that no long-term research is available to document that high-protein, low-carbo-

hydrate diets maintain weight loss any better than traditional weight-loss diets,⁵¹ what are other concerns? A major concern is that foods with proven health benefit are eliminated. There are health needs for the nutrients found in grains, fruits, vegetables, milk, and other carbohydrate-containing foods. When analyzed, these diets are seriously short of essential nutrients, such as vitamins C and D, folic acid, and especially calcium. The excess protein also has the potential to cause the body to lose what little calcium is ingested.

A typical day's menu for women from one of the popular diets reveals that it contains ~1,200 calories and less than half of the RDA for the B vitamins, iron, magnesium, zinc, and copper. The meal plan for men contains ~1,700 calories and less than half of the RDA for the B vitamins, magnesium, and copper.⁵² Taking a supplement to replace missing nutrients is not the complete solution either, because all of the essential nutrients found in foods have not yet been identified and so cannot be replaced. These diets are also low in fiber, which can contribute to constipation.

Should health professionals recommend a diet known to be nutritionally inadequate to people with diabetes in an effort to improve blood glucose control? This is an ethical question that deserves an answer.

As noted earlier, foods rich in protein are often high in fat, especially saturated fats and cholesterol, and the long-term effects on lipids from these diets is unknown. A study of subjects following a high-protein, low-carbohydrate diet for 12 weeks reported substantial increases in plasma levels of both uric acid and low-density lipoprotein cholesterol, decreases in triglycerides, but no increase in high-density lipoprotein cholesterol levels, despite effective weight loss.⁵³

With only three macronutrients to manipulate—carbohydrate, protein, and fat—there are not many options left to sell a new diet book. We have gone through the high-carbohydrate approach, and it is unlikely that a high-fat approach will go far, so we are left with recycling the high-protein diet. However, moderation is generally the best approach: eating a healthful diet, being more physically active, and keeping food records along with blood glucose records so that blood glucose levels can be kept under opti-

mal control. Although long-term research is needed, a better direction to study may be a moderate protein and carbohydrate, low-fat diet instead of the current popular high-protein, higher-fat, low-carbohydrate diets.

The bottom line: people are obese not because they eat too many carbohydrates, but because they eat too many calories. Eating carbohydrates does not make people fat unless they overeat carbohydrates (just as when they overeat protein and fat). There is evidence that high levels of dietary fat are associated with high levels of obesity,⁵⁴ but there is no evidence that high intake of "simple" sugars or carbohydrates, unless they contribute to a high caloric intake, are associated with high levels of obesity.

We are reminded that popularity is not credibility. There is little research published in peer-reviewed journals to support the low-carbohydrate, high-protein diets. High-protein diet books are based on personal experiences and testimonials and contain theories that usually would not survive peer review. Authors quote their own studies as proof. However, their studies have not shown this to be an approach that individuals can follow long-term. Long-term studies are necessary to determine how long individuals can comfortably consume a high-protein diet in the world outside of the research lab.

Focus on Blood Glucose Control, Not Weight Loss

Perhaps we need to ask why we have focused lifestyle changes for type 2 diabetes on weight loss instead of on improving blood glucose control? Certainly, all of us would like to be able to help individuals lose and maintain weight loss, but research reveals little long-term success.⁵⁰ Research is clarifying why weight loss is difficult⁵⁵⁻⁵⁷ and documenting the psychological problems associated with the dieting process.⁵⁸ Obesity is associated with the development of chronic diseases, such as type 2 diabetes, and prevention of chronic diseases may require a better understanding of what controls appetite and better tools, including medications, to prevent weight gain or assist in weight loss. However, treatment for individuals who already have type 2 diabetes needs to focus on lifestyle strategies for the improvement of the associated metabolic abnormalities.

Early in the course of the disease

when insulin resistance is present energy restriction not related to weight loss and moderate weight loss (10% of body weight or 10–20 lb) have been shown to improve insulin sensitivity.⁵⁹⁻⁶³ But as the disease progresses and insulin deficiency becomes the central issue, it may be too late for weight loss to be helpful.⁶⁴ Furthermore, mortality is not related to obesity (body mass index) in people with type 2 diabetes,^{65,66} nor is obesity associated with the micro- and macrovascular complications of diabetes.^{67,68} Many of the long-term problems associated with type 2 diabetes are associated with glycemic control.⁶⁹ Preliminary research suggests that even if weight loss is maintained over 12 months in subjects with type 2 diabetes, initial HbA_{1c} improvements are not maintained.⁷⁰

Therefore, the focus should be on controlling blood glucose (and lipid) levels, not on weight loss. Teaching people carbohydrate counting, encouraging physical activity, keeping food records, and monitoring blood glucose levels are essential.^{71,72} The diet doesn't fail; the pancreas and treatment protocol fail. Furthermore, all glucose-lowering medications work more effectively when used in combination with medical nutrition therapy.

Protein Needs and Type 2 Diabetes

It had been assumed that, in people with type 2 diabetes, abnormalities of protein metabolism are less sensitive to insufficient insulin action than those of glucose. However, studies by Gougeon et al.^{73,74} have demonstrated that moderate hyperglycemia can contribute to an increased turnover of protein in subjects with type 2 diabetes compared with an obese control group. The maintenance of body composition and nitrogen equilibrium are at the "cost" of more rapid turnover of protein and require sufficient energy and protein intakes. Insufficient protein intake does not support nitrogen equilibrium. To obtain positive nitrogen balance requires glycemic control, either via exogenous insulin or oral hypoglycemic agents (OHAs) and a higher protein intake.⁷⁴⁻⁷⁶ In contrast to subjects who did not have diabetes, euglycemia with a very-low-energy diet did not completely reestablish nitrogen equilibrium in people with type 2 diabetes.^{73,74} Furthermore, when energy is restricted, a higher protein intake is required for maintaining lean body mass while

selectively mobilizing fat.⁷⁷

This suggests that people with type 2 diabetes have an altered adaptive mechanism for protein sparing, independent of protein quality.^{73,75} Previous studies have suggested that smaller amounts of circulating insulin are sufficient to prevent protein loss in type 2 diabetes.^{78,79} It appears abnormalities of protein metabolism are present even with mild hyperglycemia. The threshold for abnormal nitrogen synthesis and breakdown is reported to be at a fasting glycemia between 6 and 7 mmol/l (108–125 mg/dl).⁸⁰ Therefore, with moderate energy restriction there is need for a generous dietary protein intake (~1 g/kg body weight). However, this is not more than the amount of protein consumed on a usual basis by people with type 2 diabetes. Treatment of type 2 diabetes that consists of OHAs or insulin, moderate energy restriction, and adequate protein intake not only improves glucose and lipids, but also is able to correct several aspects of whole-body protein metabolism.

Protein Needs and Type 1 Diabetes

Protein degradation and conversion of both endogenous and exogenous protein to glucose in type 1 diabetes depends on the state of insulinization and degree of glycemic control. In insulin-deficient individuals, both limited and excess dietary protein can have adverse effects. Conversion of excess dietary or endogenous protein to glucose may adversely influence glycemic regulation. On the other hand, these individuals might be more susceptible to body protein loss during dietary protein restriction. Definitive answers to these concerns are still unknown.⁸¹

Insulin deficiency increases both whole-body protein synthesis and protein breakdown with oxidation of essential amino acids.⁸² However, the synthesis and degradation might not involve the same proteins. Gluconeogenesis also is increased, and hepatic extraction of alanine, a key amino acid gluconeogenic precursor, is accelerated.¹⁹ Excessive rates of hepatic glucose production, proteolysis, and amino acid oxidation in type 1 diabetes are all reduced by insulin administration,⁸² but proteolysis and amino acid oxidation are more resistant to the suppressive effects of insulin.⁸³ Normalization of protein metabolic rates may, therefore, require long-term tight metabolic control.⁸⁴ Today,

with improved glycemic management in type 1 diabetes, a more normal protein synthesis, breakdown, and oxidation should occur.

Summary

Let's review recommendations given to people with diabetes in regard to protein and try to determine if the research supports any or all of them.

- “Proteins are foods like meat, cheese, and peanut butter.” Only partly true; in most cases these foods are protein-plus-fats.
- “Between 50–60% of protein becomes glucose and enters the bloodstream about 3–4 hours after eaten.” Perhaps 50–60% of protein goes through the process of gluconeogenesis in the liver, but virtually none of this glucose enters into the general circulation.
- “Don't eat fruit, fruit juice, or a sweet for a snack without also eating a source of protein to slow the absorption of carbohydrate.” In none of the studies reviewed did added protein slow or change the peak postprandial glucose response.
- “Bedtime snacks should always contain protein.” No clear answer is available, but protein may not be needed. Even if protein is added, the effect on blood glucose levels is not great. However, people with diabetes (without renal disease) can be advised to eat an extra serving of protein rather than carbohydrate at meals or for snacks if they are still hungry after eating their usual carbohydrate servings.
- “Treat an insulin reaction with a fast-acting carbohydrate, and add protein to provide a later source of blood glucose. This will prevent the blood glucose from dropping too low again.” One small study concluded that adding protein to the treatment of hypoglycemia only added unwanted or unneeded calories. Would this also be true when protein is added to bedtime snacks? Furthermore, the term “fast-acting carbohydrate” should be eliminated.
- “Eating too much protein can damage the kidneys.” In people with diabetes, no evidence supports the claim that protein intakes <20% of total daily caloric intake contribute to the development of renal disease.

What about the high-protein, low carbohydrate diets? Initial results are often dramatic in terms of weight loss and impact on glycemia, but no long-term controlled clinical research has

been done. We do not know if individuals follow these types of diets any better long-term than other low-calorie diets or whether weight loss would be maintained if they did. We also do not know the long-term effect of such diets on blood glucose levels and overall health.

Although protein ingestion increases circulating insulin in all people, in obese people with type 2 diabetes, the insulin secretion to protein is greater than in subjects without diabetes.^{10,85} In people without diabetes, protein is a relatively weak stimulant of insulin compared to glucose,⁹ while in people with type 2 diabetes who are still able to secrete considerable amounts of insulin, protein and carbohydrate are equal in stimulating insulin response, and when combined the insulin response is additive in people without diabetes but is synergistic in people with type 2 diabetes.^{9,10} Stimulating endogenous insulin can be viewed as a positive or a negative—negative because of the potential endogenous hyperinsulinemia and its association with insulin resistance and cardiovascular disease; positive because protein ingested with carbohydrate can have a synergistic effect on insulin, thus improving the postprandial response to carbohydrate.

Obtaining positive nitrogen balance in people with type 2 diabetes requires glycemic control and adequate protein intake, especially when energy intake is restricted. Fortunately, the large amount of protein in the customary diet of people with diabetes compensates for the increased protein catabolism and thus protects from protein malnutrition.⁸⁶

In people with type 1 diabetes, the effect of protein on glycemia will be dependent on the state of insulinization and the degree of glycemic control. Protein requires insulin for metabolism, as do carbohydrate and fat, but has minimal effects on blood glucose levels. In well-controlled diabetes, large amounts of protein have the potential to contribute to glucose production, minimally increase blood glucose levels, and require additional small amounts of insulin. If protein is decreased, insulin doses may also need to be decreased. There is limited evidence to suggest that protein contributes to a sustained elevation of blood glucose levels, slows absorption of carbohydrate, or is helpful for the treatment of hypoglycemia.

Finally, the focus should shift from

debating the ideal percentages of calories from macronutrients and instead should focus on the goals of diabetes medical nutrition therapy and strategies known to assist in achieving these goals. Nutrition recommendations must be individualized based on treatment goals and an assessment of what the individual is currently eating, what changes might be beneficial, and the changes the individual is willing and able to make. People with diabetes need accurate information on which to base their decisions, because ultimately they make the final decision as to what they will eat.

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