Exaggerated Hyperglycemia After A Pizza Meal in Well-Controlled Diabetes

JO ANN AHERN, RN, BSN, CDE
PATRICIA M. GATCOMB, RN, BSN, CDE
NANCY A. HELD, MS, RD, CDE
WILLIAM A. PETIT, JR., MD
WILLIAM V. TAMBORLANE, MD

OBJECTIVE — To examine whether the postprandial hyperglycemic effect of pizza in well-controlled IDDM patients is related to overeating or to unique properties of this popular food.

RESEARCH DESIGN AND METHODS — On two evenings, each patient (n = 8) consumed a meal that was similar in macronutrient composition except that one consisted of pizza and the other was a control meal that included high glycemic index foods. The insulin regimen was held constant.

RESULTS — Postprandial glucose levels were within the target range (≤10 mM) after the control meal. Although the initial glucose increase was similar for the two meals, plasma glucose continued to rise and was significantly increased from 4 to 9 h after ingestion of pizza compared with the control meal ($P < 0.05$). This increase occurred even though free insulin, glucagon, and free fatty acid levels did not differ significantly.

CONCLUSIONS — Our data suggest that pizza has properties that accentuate and sustain postprandial hyperglycemia.

In our practice, the ingestion of pizza by well-controlled IDDM patients seemed to be followed by overnight hyperglycemia, even when extra regular insulin was prescribed before the meal to control the early postprandial rise in glucose. These observations suggested that hyperglycemia after a pizza meal was not simply because of overeating but might be a consequence of the unique composition of pizza. To evaluate this question, the effect of pizza on metabolic parameters in the early and late postprandial periods was compared with a control meal identical in calories and similar in macronutrient composition in a group of intensively treated IDDM patients.

RESEARCH DESIGN AND METHODS

— Six men and two women (body weight 69 ± 9 kg, 35 ± 7 yr of age) with C peptide–negative IDDM were studied. To be eligible, the patients had to be on a regimen consisting of MDI (n = 6) or CSII (n = 2) and have a duration of IDDM >3 yr (mean 9 ± 2 yr), an HbA_1 <7.5% (mean 6.7 ± 0.2%, 3SD above the mean for normal control subjects), a blood glucose of 3.3–8.9 mM at the start of the study, and no clinical evidence of autonomic neuropathy.

All subjects were admitted twice to the Clinical Research Center at 1630, and an intravenous catheter was inserted into an antecubital vein for blood drawing. The subjects received their usual presupper dose of insulin 15 min before the test meal, which consisted of either pizza or a control meal given in random order. Blood samples were obtained before and for 13 h after ingestion of the test meal for measurements of glucose, free insulin, glucagon, and FFAs.

The patients were instructed to maintain the same activities, diet, and insulin on both study days. In all subjects, basal and premeal bolus insulin doses were the same on both study days and were identical to what the patients were receiving at home. The MDI patients were receiving only regular insulin before supper and NPH insulin at bedtime. The total daily insulin dose in the patients averaged 0.7 $U \cdot kg^{-1} \cdot day^{-1}$.

Pizza was prepared by the staff of the metabolic research kitchen on the evening of study and was specifically designed to be as similar to a typical pizzeria pizza as possible (Table 1). The recipe was based on informal surveys of local pizzerias and experimentation in the research kitchen. The size of the

FROM THE DEPARTMENT OF NURSING, YALE–NEW HAVEN HOSPITAL; AND THE DEPARTMENT OF PEDIATRICS, INTERNAL MEDICINE, AND THE GENERAL CLINICAL RESEARCH CENTERS, YALE UNIVERSITY SCHOOL OF MEDICINE, NEW HAVEN, CONNECTICUT.

ADDRESS CORRESPONDENCE AND REPRINT REQUESTS TO JO ANN AHERN, RN, BSN, CDE, H530, YALE–NEW HAVEN HOSPITAL, 20 YORK STREET, NEW HAVEN, CT 06504.

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IDDM, INSULIN-DEPENDENT DIABETES MELLITUS; FFA, FREE FATTY ACID; MDI, MULTIPLE DAILY INJECTIONS; CSII, CONTINUOUS SUBCUTANEOUS INSULIN INFUSION; ANOVA, ANALYSIS OF VARIANCE.

Table 1—*Composition of the two test meals*

	Pizza meal	Control meal
Energy (kcal)	1300	1300
Fiber	7.3	10.8
Protein (%)	18	18
Fat (%)	44	44
Carbohydrate (%)	38	38
Mono- and disaccharides (g)	17.9	65.6
Fructose (g)	5.7	30.0
Canned tomatoes (g)	336	White bread (g) 40
Tomato paste (g)	23.5	Margarine (g) 25
Olive oil (g)	17.2	Mayonnaise (g) 20
Onion (g)	22	Turkey (g) 138
Garlic (g)	1.4	Cheese (g) 40
Sugar (g)	6.7	Baked potato (g) 150
Parmesan cheese (g)	11.6	Lettuce (g) 50
Whole-milk mozzarella (g)	194.5	Fresh tomato (g) 30
White flour (g)	119.2	Vegetable oil (g) 14
Yeast (g)	2.3	Vinegar (g) 4
Salt (g)	1.4	Raisins (g) 40
Spices (g)		Apple juice (g) 262

meals was based on calories consumed during a typical dinner and bedtime snack; no bedtime snacks or bedtime doses of regular insulin were taken on either study day.

Both meals consisted of the same calories and macronutrient composition based on standard food tables (Table 1). The control meal was designed to include high glycemic index foods, and both meals were consumed within 20 min.

Determinations and statistical analysis

Plasma glucose was determined with a glucose analyzer (Beckman Instruments, Fullerton, CA). For assays of free insulin, plasma samples were treated with polyethylene glycol to precipitate antibody-bound insulin immediately after separation; the resultant free insulin was measured within 4 wk (1). Plasma FFA was measured by colorimetric method (2). Glucagon was measured by a double-antibody radioimmunoassay (ICN Biomedicals, Costa Mesa, CA). Two-way ANOVA (time and meal study group assignment) was used to compare differences in the metabolic responses to the two test meals. Where the ANOVA was significant, contrasts in means were compared with paired Student's *t* tests. Data are presented as means ± SE.

RESULTS — Plasma glucose profiles before and after the control and pizza meals are shown in Fig. 1. As can be seen, the patients had preprandial plasma glucose levels within the normal range before both test meals (5.1 ± 0.7 vs. 4.7 ± 0.6 mM, before pizza and control meals, respectively). Satisfactory control of postprandial glycemia was observed in these intensively treated IDDM patients after the control meal and the pizza meal. On the other hand, plasma glucose values were significantly elevated on the pizza night between bedtime and the next morning.

Higher plasma glucose levels were observed after the pizza meal, even though the premeal doses of regular insulin were identical (8.8 ± 2.4 U) on both study days. As shown in Fig. 1, baseline plasma insulin was slightly greater before supper on the pizza meal than the control meal day and slightly lower after supper. However, those differences were not significant. Moreover, the area under the plasma insulin curve was similar on the pizza and control meal days (13.6 ± 1.4 and 14.7 ± 1.1 M/min, respectively). Plasma glucagon and FFA levels were also similar before and after both test meals (data not shown).

CONCLUSIONS — The results of this study confirm our clinical impression that ingestion of pizza leads to problems with late postprandial hyperglycemia in well-controlled, intensively treated IDDM patients. An exaggerated glycemic excursion was observed after consumption of pizza even compared with that seen after a control meal comprised of the same energy content and similar proportions of macronutrients and fiber

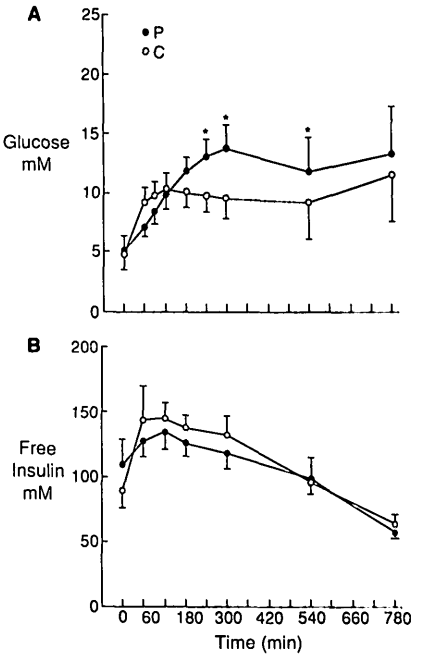

Figure 1—*Plasma glucose (A) and insulin (B) levels before and after pizza meal (●) and control meal (○) in intensively treated IDDM patients. Data are means ± SE. *P < 0.05 vs. control meal.*

content (3). Moreover, plasma glucose levels were higher after pizza despite identical premeal insulin doses and similar plasma insulin, glucagon, and FFA levels. We cannot rule out the possibility that the small and statistically insignificant differences in free insulin levels on the two study days may have contributed to the differences in glycemic excursions.

Different foods with identical composition of macronutrients are digested and absorbed at different rates. As a result, they produce a range of glycemic responses in diabetic patients that can be predicted, at least in part, from their glycemic indexes. Note that in this study more pronounced hyperglycemia was observed in the late postprandial period after pizza than after the standard meal that included several high glycemic index foods (4–7) and a greater amount of fructose. The greater amount of polysaccharides (8) or other components like olive oil or spices may have contributed to the persistent hyperglycemia after the pizza meal.

Although the mechanism remains to be established, our findings indicate that the problems with postprandial hyperglycemia after pizza are, at least in part, caused by the nature of pizza itself and not merely by overeating. Because the hyperglycemia induced by pizza was most pronounced in the late postprandial period, simply increasing the premeal dose of regular insulin may not be sufficient to compensate for the problem. It remains to be established whether a similar effect would be seen in patients who are not receiving intensive insulin regimens and are less well controlled. Perhaps in those patients, other factors would contribute to a greater extent to postprandial hyperglycemia so that any effect of pizza would not be evident.

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References

1. Nakagawa S, Nakayama H, Sasaki T, Yoshino K, Yu YY, Shinozaki K, Aoki S, Mashimo K: A simple method for the determination of serum free insulin levels in insulin treated patients. *Diabetes* 22:590–600, 1973
2. Novak M: Colorimetric ultramicro method for the determination of free fatty acids. *J Lipid Res* 6:431–33, 1965
3. Anderson, JW: *Plant Fiber in Foods*. Lexington, KY, HCF Diabetes Research Foundation, 1986
4. Hughes TA, Atchinson J, Hazelrig JB, Boshell BR: Glycemic response in insulin-dependent diabetic patients: effect of food composition. *Am J Clin Nutr* 49:658–66, 1989
5. Jenkins DJA, Taylor RH, Woelver TMS: The diabetic diet, dietary carbohydrate and differences in digestibility. *Diabetologia* 23:477–84, 1982
6. Woelver TMS, Jenkins DJA: The use of the glycemic index in predicting the blood glucose response to mixed meals. *Am J Clin Nutr* 43:167–72, 1986
7. Woelver TMS, Nuttall FQ, Lee R, Wong G, Josse R, Csima A, Jenkins DJA: Prediction of the relative blood glucose response of mixed meals using the white bread glycemic index. *Diabetes Care* 8:418–28, 1985
8. Ahern JA, Gatcomb, PM, Held N, Tamborlane WV: Pizza induces an exaggerated glycemic response in well-controlled IDDM patients (Abstract). *The Diabetes Educator* 16:336, 1990