Vinegar Improves Insulin Sensitivity to a High-Carbohydrate Meal in Subjects With Insulin Resistance or Type 2 Diabetes

The number of Americans with type 2 diabetes is expected to increase by 50% in the next 25 years; hence, the prevention of type 2 diabetes is an important objective. Recent large-scale trials (the Diabetes Prevention Program and STOP-NIDDM) have demonstrated that therapeutic agents used to improve insulin sensitivity in diabetes, metformin and acarbose, may also delay or prevent the onset of type 2 diabetes in high-risk pop-

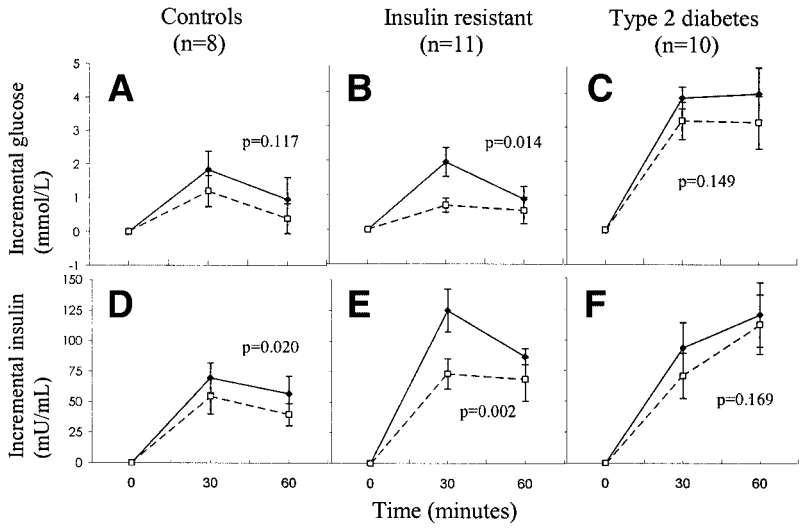

Figure 1—*Effects of vinegar (□) and placebo (◆) on plasma glucose (A–C) and insulin (D–F) responses after a standard meal in control subjects, insulin-resistant subjects, and subjects with type 2 diabetes. Values are means ± SE. The P values represent a significant effect of treatment (multivariate ANOVA repeated-measures test).*

ulations. Interestingly, an early report showed that vinegar attenuated the glucose and insulin responses to a sucrose or starch load (1). In the present report, we assessed the effectiveness of vinegar in reducing postprandial glycemia and insulinemia in subjects with varying degrees of insulin sensitivity.

Our study included nondiabetic subjects who were either insulin sensitive (control subjects, $n = 8$) or insulin resistant ($n = 11$) and 10 subjects with type 2 diabetes. Subjects provided written informed consent and were not taking diabetes medications. Fasting subjects were randomly assigned to consume the vinegar (20 g apple cider vinegar, 40 g water, and 1 tsp saccharine) or placebo drink and, after a 2-min delay, the test meal, which was composed of a white bagel, butter, and orange juice (87 g total carbohydrates). The cross-over trial was conducted 1 week later. Blood samples were collected at fasting and 30 and 60 min postmeal for glucose and insulin analyses. Whole-body insulin sensitivity during the 60-min postmeal interval was estimated using a composite score (2).

Fasting glucose concentrations were elevated ~55% in subjects with diabetes compared with the other subject groups ($P < 0.01$, Tukey's post hoc test), and fasting insulin concentrations were elevated 95–115% in subjects with insulin resistance or type 2 diabetes compared with control subjects ($P < 0.01$). Compared with placebo, vinegar ingestion raised whole-body insulin sensitivity during the 60-min postmeal interval in insulin-resistant subjects (34%, $P = 0.01$, paired t test) and slightly improved this parameter in subjects with type 2 diabetes (19%, $P = 0.07$). Postprandial fluxes in insulin were significantly reduced by vinegar in control subjects, and postprandial fluxes in both glucose and insulin were significantly reduced in insulin-resistant subjects (Fig. 1).

These data indicate that vinegar can significantly improve postprandial insulin sensitivity in insulin-resistant subjects. Acetic acid has been shown to suppress disaccharidase activity (3) and to raise glucose-6-phosphate concentrations in skeletal muscle (4); thus, vinegar may possess physiological effects similar to acarbose or metformin. Further investigations to examine the efficacy of vinegar as an antidiabetic therapy are warranted.

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