Decaffeinated Coffee and Glucose Metabolism in Young Men

JAMES A. GREENBERG, PHD[1]
DAVID R. OWEN, PHD[2]
ALLAN GELIEBTER, PHD[3]

OBJECTIVE — The epidemiological association between coffee drinking and decreased risk of type 2 diabetes is strong. However, caffeinated coffee acutely impairs glucose metabolism. We assessed acute effects of decaffeinated coffee on glucose and insulin levels.

RESEARCH DESIGN AND METHODS — This was a randomized, cross-over, placebo-controlled trial of the effects of decaffeinated coffee, caffeinated coffee, and caffeine on glucose, insulin, and glucose-dependent insulinotropic polypeptide (GIP) levels during a 2-h oral glucose tolerance test (OGTT) in 11 young men.

RESULTS — Within the first hour of the OGTT, glucose and insulin were higher for decaffeinated coffee than for placebo ($P < 0.05$). During the whole OGTT, decaffeinated coffee yielded higher insulin than placebo and lower glucose and a higher insulin sensitivity index than caffeine. Changes in GIP could not explain any beverage effects on glucose and insulin.

CONCLUSIONS — Some types of decaffeinated coffee may acutely impair glucose metabolism but less than caffeine.

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Nineteen of 22 epidemiological studies concluded that long-term consumption of coffee, both caffeinated and decaffeinated, can reduce the risk of type 2 diabetes (1–3), but several investigators have warned that the caffeine in caffeinated coffee can impair glucose metabolism (e.g., 4,5). While decaffeinated coffee contains very little caffeine and may safely protect against diabetes, there have been conflicting reports on decaffeinated coffee's acute effects on glucose metabolism (6–9). Our objective was to assess whether ground decaffeinated coffee enhances glucose metabolism and whether glucose-dependent insulinotropic polypeptide (GIP), an incretin hormone that stimulates insulin secretion (10), plays a causal role.

RESEARCH DESIGN AND METHODS

Eleven healthy male nonsmokers signed an informed consent and participated. The following participation requirements were started 1 week prior to the first lab visit: keep diet, exercise, and alcohol intake stable; no caffeinated drinks, foods, or medications; no smoking; and no alcohol or exercise during the 48 h prior to each visit.

There were four visits separated by at least a week. Participants ingested one of four beverages assigned by researchers in a single-blinded randomized fashion at a temperature of 43–49°C (caffeinated coffee, decaffeinated coffee, caffeine in warm water, or warm water [placebo]). An oral glucose tolerance test (OGTT) was initiated 1 h later ($t = 0$ min) with ingestion of 75 g of glucose in water. Blood was drawn at time −90, −60, 0, 10, 30, 60, 90, and 120 min.

Participants drank 500–600 ml of drip-filtered ground coffee (Chock Full O'Nuts Original; Massimo Zanetti Beverage, Portsmouth, VA). The recipe was eight cups of water with 40 g of grounds for caffeinated and 57 g of grounds for decaffeinated coffee. For the caffeine and hot water (placebo) beverages, we ran eight cups of water through the machine with filter paper without coffee grounds. For the caffeine beverage, we added food-grade caffeine powder (Spectrum Chemical Manufacturing, Gardena, CA). The volume ingested was the same for each beverage and differed by participant to yield 6 mg caffeine/kg of body wt in the caffeine and caffeinated coffee beverage. The caffeine content of the caffeinated coffee was measured as 0.73 mg/ml coffee, by high-performance liquid chromatography.

Glucose was assayed in plasma using the oxygen rate method (Beckman Glucose Analyzer 2; Beckman, Brea, CA). Insulin was assayed in plasma (human-specific radioimmunoassay kit no. M114886; Millipore, Billerica, MA). GIP (total) was measured in plasma (human GIP [total] enzyme-linked immunosorbent assay kit no. M116520; Millipore).

The trapezoidal rule was used to calculate area under the curve (AUC). The insulin sensitivity index (ISI) was calculated using the formula of Belfiore et al. (11). All blood data were analyzed for time and beverage effects using two-way repeated-measures ANOVA. AUC and ISI data were analyzed using one-way repeated-measures ANOVA. All tests were adjusted for multiple comparisons by means of Tukey Studentized range adjustments. Two-sided $P < 0.05$ was considered significant. We used SPSS 11.5 for all statistical analyses.

RESULTS

The subjects had a mean (± SD) age of 23.5 ± 5.7 years, BMI 23.6 ± 4.2 kg/m^2, fasting glucose 4.41 ± 0.49 pmol/l, and fasting insulin 109.0 ± 91.7 pmol/l. Participants reported no nonminor adverse reactions.

During the first 30 min of the OGTT, decaffeinated coffee yielded significantly higher glucose than placebo (Table 1).

From the [1]Department of Health and Nutrition Sciences, Brooklyn College of the City, University of New York, New York, New York; the [2]Department of Psychology, Brooklyn College of the City, University of New York, New York, New York; and the [3]Department of Psychology, Columbia University and New York Obesity Research Center, St. Luke's Roosevelt Hospital Center, New York, New York.
Corresponding author: James Greenberg, jamesg@brooklyn.cuny.edu.
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Glucose AUC for decaffeinated coffee was significantly lower than for caffeine. Insulin was significantly higher after caffeine and decaffeinated coffee than after placebo during the first hour of the OGTT. Insulin AUC was significantly higher for caffeine and decaffeinated coffee than for placebo.

ISI (means ± SE) was 1.22 ± 0.07 for placebo, 0.98 ± 0.09 for caffeine, 1.09 ± 0.08 for decaffeinated coffee, and 0.97 ± 0.09 for caffeinated coffee. ISI for decaffeinated coffee was significantly higher than for caffeine and showed a trend toward being lower than for placebo (P = 0.052). Caffeinated coffee induced effects on glucose and insulin that were similar to those for caffeine. GIP decreased after ingestion of all beverages and became significantly lower for decaffeinated coffee than for caffeine and placebo 60 min after beverage ingestion.

CONCLUSIONS — Decaffeinated coffee acutely impaired glucose metabolism in healthy young men. Within the first 60 min of the OGTT, both glucose and insulin were significantly higher after decaffeinated coffee than after placebo. During the whole OGTT, insulin AUC was significantly higher for decaffeinated coffee than placebo. Decaffeinated coffee did not impair glucose metabolism as severely as caffeine. During the whole OGTT, decaffeinated coffee yielded lower glucose AUC and higher ISI than caffeine. Our findings require confirmation in future studies. However, they do suggest that caution is needed in the quest to harness coffee's potential to reduce the risk of diabetes, demonstrated in epidemiological studies.

Battram et al. (6) found an acute enhancement of glucose metabolism by ground decaffeinated coffee, and Johnston et al. (7), Thom (8), and van Dijk et al. (9) found no acute effect on glucose metabolism by instant decaffeinated coffee. It is possible that our decaffeinated coffee had a higher concentration of caffeine (12) than the decaffeinated coffees of these investigators, or that our decaffeinated coffee had lower concentrations of noncaffeine compounds, which acutely enhance glucose metabolism. It seems unlikely that GIP played a role in our observed beverage effects. For example, 60 min after beverage ingestion, decaffeinated coffee yielded significantly lower GIP than placebo and caffeine but no significant changes in insulin or glucose.

Table 1—*Glucose, insulin, and GIP concentrations and AUC during an OGTT following ingestion of placebo, decaffeinated coffee, caffeinated coffee, and caffeine in 11 healthy young men*

	$T = -90$	$T = -60$	$T = 0$	$T = 10$	$T = 30$	$T = 60$	$T = 90$	$T = 120$	3-h AUC
Glucose (mmol/l)									
Placebo	4.50 ± 0.15	4.25 ± 0.14	4.35 ± 0.19	4.57 ± 0.20[a]	6.66 ± 0.28[a]	7.38 ± 0.70	6.95 ± 0.79	5.45 ± 0.57	4.35 ± 1.01[a,b]
Decaffeinated coffee	4.55 ± 0.17	4.34 ± 0.16	4.44 ± 0.18	5.25 ± 0.28[b]	8.13 ± 0.41[b]	6.86 ± 0.61	5.99 ± 0.48	5.09 ± 0.45	4.1 ± 0.67[b]
Caffeinated coffee	4.29 ± 0.14	4.29 ± 0.09	4.62 ± 0.11	5.51 ± 0.26[b]	7.63 ± 0.39[b]	8.11 ± 0.43	7.14 ± 0.32	5.96 ± 0.35	5.63 ± 0.38[a,b]
Caffeine	4.33 ± 0.13	4.18 ± 0.14	4.31 ± 0.12	5.04 ± 0.18[b]	7.44 ± 0.26[b]	7.87 ± 0.75	7.00 ± 0.69	6.05 ± 0.64	5.39 ± 0.80[a]
Insulin (Φmol /l)									
Placebo	105.3 ± 33.3	85.1 ± 25.6	71.2 ± 17.4	124.8 ± 21.7[a]	331.2 ± 51.8[a]	421.4 ± 44.0[a]	413.4 ± 51.2	296.4 ± 55.2	489.4 ± 75.8[a]
Decaffeinated coffee	114.7 ± 28.4	80.2 ± 11.0	71.0 ± 9.9	231.0 ± 54.8[b]	537.4 ± 97.1[b]	518.1 ± 56.7[b]	489.8 ± 99.7	316.3 ± 54.5	705.5 ± 109.8[b]
Caffeinated coffee	102.7 ± 22.7	87.7 ± 10.7	75.7 ± 9.1	238.4 ± 59.1[b]	544.7 ± 97.4[b]	626.2 ± 109.6[b]	692.3 ± 140.7	457.2 ± 110.0	884.9 ± 159.4[b]
Caffeine	113.3 ± 29.0	103.7 ± 30.1	76.9 ± 10.8	202.9 ± 32.8[b]	555.8 ± 85.6[b]	717.8 ± 127.3[b]	669.8 ± 140.1	480.8 ± 124.8	882.0 ± 185.9[b]
GIP (pg/ml)									
Placebo	68.8 ± 15.3	65.0 ± 14.6	58.4 ± 16.9[a]	106.7 ± 17.7	157.3 ± 18.2	164.6 ± 17.1	166.0 ± 18.4	143.2 ± 17.9	164.9 ± 23.0[a]
Decaffeinated coffee	131.0 ± 31.9	91.3 ± 18.5	44.2 ± 7.1[b]	130.4 ± 13.4	187.4 ± 24.7	173.8 ± 20.4	160.1 ± 19.0	136.9 ± 16.9	109.4 ± 35.6[a]
Caffeinated coffee	83.5 ± 24.9	72.3 ± 14.0	43.8 ± 8.5[a,b]	120.2 ± 22.0	158.3 ± 23.2	148.1 ± 17.8	134.1 ± 12.9	124.0 ± 13.4	112.7 ± 30.2[a]
Caffeine	88.0 ± 29.1	77.7 ± 19.6	67.2 ± 10.8[a]	141.3 ± 28.3	174.6 ± 27.3	166.8 ± 20.5	159.3 ± 21.7	139.2 ± 21.7	150.8 ± 34.6[a]

Data are means ± SEM. n = 11. T denotes time point in minutes. Initial values ($T = -90$ min) are fasting values. Beverage ingested at $T = -60$ min. OGTT started at $T = 0$ min. ISI was based on the formula of Belfiore et al. (11). Three-hour AUC was calculated between $T = -60$ and $T = 120$. Means in a column with different letter superscripts differ significantly ($P < 0.05$), by two-way repeated-measures ANOVA for glucose and insulin and by one-way repeated-measures ANOVA for 3-h AUC. Post-hoc tests adjusted for multiple comparisons by means of a Tukey test.

Our study has several limitations. We only had 11 volunteers. More volunteers would have yielded more statistical power. Our study also has some strengths. Our protocol allowed us to convincingly separate the effects of each beverage from the effects of the OGTT glucose because ingestion of the beverages was separated by 60 min from ingestion of the glucose.

In conclusion, our human trial appears to be the first to find that decaffeinated coffee can acutely impair glucose metabolism, but less than caffeine, in healthy young men.

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No potential conflicts of interest relevant to this article were reported.

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