Factors Associated With Glucose and Insulin Levels in Healthy Postmenopausal Women

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OBJECTIVE — Little is known about the covariates of hyperglycemia and hyperinsulinemia. We examined candidate factors in postmenopausal women.

RESEARCH DESIGN AND METHODS — We determined the cross-sectional associations of sociodemographic, body-size, lifestyle, reproductive, and menopausal factors with pretrial fasting and postchallenge glucose and insulin levels in 869 postmenopausal women aged 45–65 years. Women were participants in the Postmenopausal Estrogen/Progestin Interventions study who were not taking estrogen or insulin.

RESULTS — Plasma glucose levels increased significantly with age; serum insulin levels did not. BMI and waist-to-hip ratio (WHR) each showed graded positive and independent associations with glucose and insulin levels. Alcohol intake, cigarette smoking, physical activity, parity, education, and income were also associated with insulin or glucose in age-adjusted models. In multivariable models, BMI and WHR explained 18% of the variability in fasting glucose, 16% in postchallenge glucose, 28% in fasting insulin, and 17% in postchallenge insulin. Age and all other factors combined accounted for <6% of the variance in glucose or insulin. In multiply adjusted models, African-American and Hispanic women had higher fasting and 2-h insulin levels than non-Hispanic white women.

CONCLUSIONS — Most of the variance in glycemia and insulin is unexplained. Measures of obesity and fat distribution account for nearly all the explained variance.

Diabetes and impaired glucose tolerance are associated with hyperinsulinemia and an increased risk of heart disease (1–3), but few studies have systematically examined factors associated with glycemia or hyperinsulinemia in women. The best known covariates of serum insulin levels are obesity, particularly central (abdominal) obesity, and abnormal carbohydrate tolerance (4), but there is an approximately fourfold variation in insulin-stimulated glucose uptake in hyperinsulinemic individuals with normal glucose tolerance (5). It is uncertain whether other possible covariates, such as physical activity and parity, affect glucose and insulin levels independently or via an effect on obesity and fat pattern (6). Oral contraceptives may worsen glucose tolerance (7–9), whereas postmenopausal estrogen may have a salutary effect (10,11). However, the consequences of prior use of contraceptive and noncontraceptive hormones on glucose and insulin levels are unknown.

We report here the factors associated with prerandomization glucose and insulin levels in 869 healthy postmenopausal women from the Postmenopausal Estrogen/Progestin Interventions (PEPI) trial.

RESEARCH DESIGN AND METHODS

— A detailed description of the PEPI trial appears elsewhere (12–15). Briefly, postmenopausal women were recruited from seven communities (for location and investigators, see APPENDIX). All were ambulatory and gave written informed consent. Menopausal status was based on years since last menstrual period and elevated follicle-stimulating hormone level. Women who were currently taking insulin or who had taken estrogen within the past 3 months were not included. Exclusion criteria possibly relevant to glucose tolerance included BMI ≥40, blood pressure ≥160 mmHg systolic or ≥95 diastolic, fasting plasma glucose levels ≥140 mg/dl (≥7.7 mmol/l), and triglyceride levels ≥400 mg/dl (4.5 mmol/l).

A standard 75-g oral glucose tolerance test was performed between 7:00 and 11:00 A.M. after a 12-h fast; women were instructed to take 5–10 min to consume the glucose drink. Venous blood for glucose was collected in EDTA tubes, placed on ice immediately, and centrifuged within 20 min. Blood for insulin was centrifuged after ~45 min at room temperature. Frozen plasma and insulin were mailed on dry ice to the PEPI Central Insulin/Glucose Laboratory at the University of Indiana. Plasma glucose was measured using a colorimetric glucose oxidase method after Somogyi precipitation (16). The interassay coefficients of variation during PEPI analyses, based on Boehringer Mannheim Diagnostics control pools, were 2.0 and 1.8% for target glucose values of 71 and 290 mg/dl, respectively. Serum insulin levels were assayed in duplicate using a minor modification of a double antibody method (17). Based on analysis of Bio-Rad control pools, interassay coefficients of variation were 29, 14, and 13% for insulin target

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Received for publication 21 February 1995 and accepted in revised form 13 November 1995.

PEPI, Postmenopausal Estrogen/Progestin Interventions; WHR, waist-to-hip ratio.

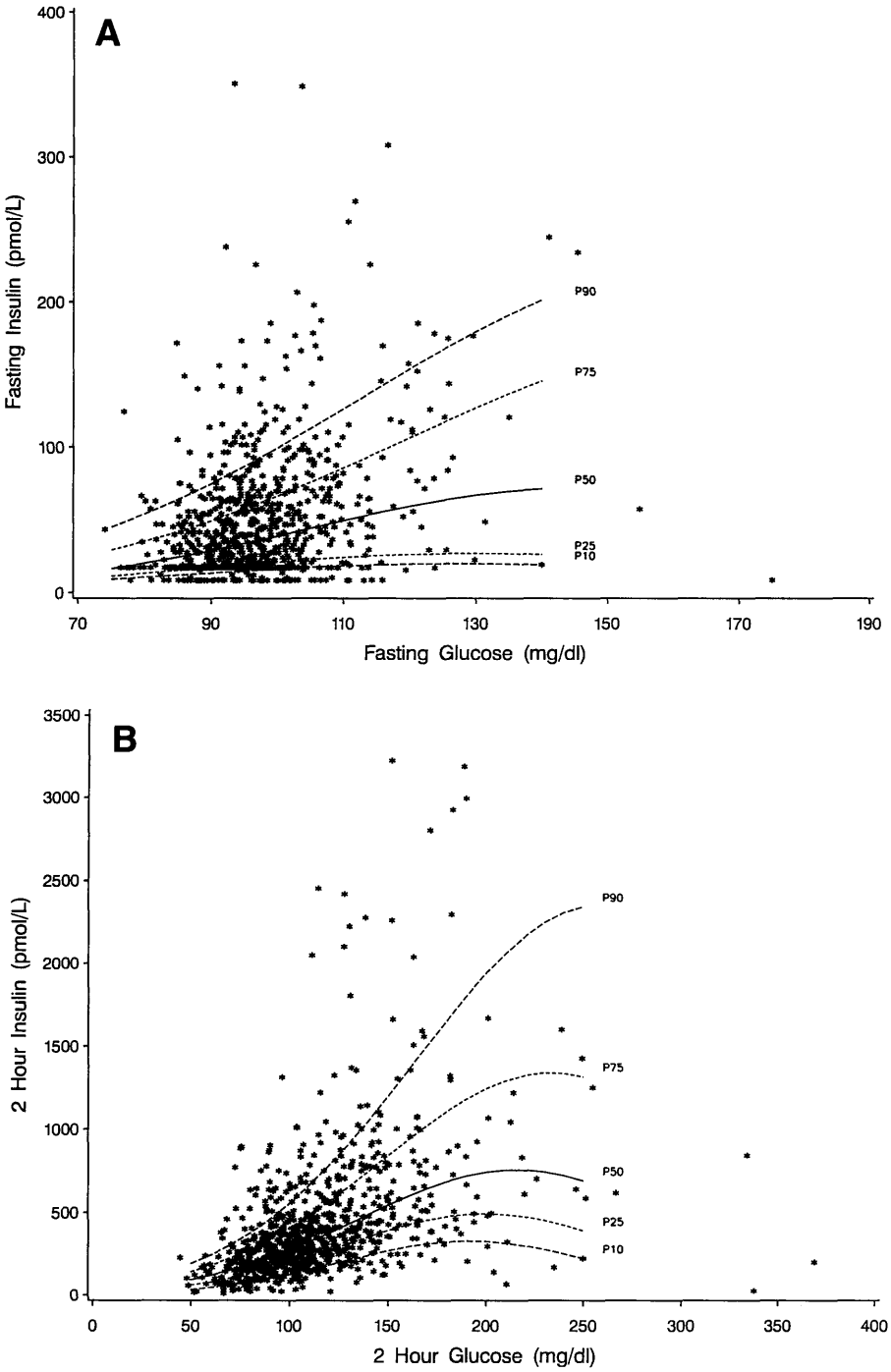

Figure 1—*Correlation of fasting insulin with fasting glucose* (A) (r = *0.30;* P < *0.0001) and 2-h insulin with 2-h glucose* (B) (r = *0.25;* P < *0.0001).*

values of 0.28, 1.7, and 3.7 ng/ml, respectively.

Other relevant covariates were determined by standardized interview. Cigarette smoking was reported as current, past, and never. Alcohol intake was reported as never, past, and current drinks per day. Customary physical activity during the past 12 months was classified for home, work, and leisure activity as none, light, moderate, or heavy, based on examples of each level of activity given in the questionnaire. Height, weight, and waist and hip circumferences were measured with subjects wearing light clothing and no shoes. BMI was used as an estimate of obesity, and waist-to-hip ratio (WHR) was used as an estimate for central obesity.

Statistical analysis

Only factors associated with fasting and 2-h glucose are reported, because the inclusion of 1-h values and the area under the curve added little information. Because insulin levels were positively skewed, analyses of these data were performed on logarithms; means, percentile contours, and standard deviations (18) were transformed back to their original scales. Percentile contours for insulin versus glucose levels were constructed using asymmetric least squares regression with quadratic models (19). Two insulin data points >5,000 pmol/l were excluded.

Analyses of covariance were used to assess the univariate relationships each graded or discrete predictor had with glucose and insulin after controlling for age. Least squares regression was used to assess the independent contribution of factors predicting glucose and insulin levels. Relationships with age, BMI, and WHR were first explored. Forward stepwise selection was then used to add additional predictors to the models in the order in which they contributed the most to prediction (in terms of R^2). All factors associated with a nominal *P* value <0.10 were included.

RESULTS— The average age of the 869 women was 56 years (range 45–65). There was a positive, graded, and significant relation between age and plasma glucose ($r = 0.16$, $P < 0.0001$ for fasting glucose; $r = 0.18$, $P < 0.0001$ for 2-h glucose). No significant association between age and serum insulin was found ($r = 0.03$, $P = 0.46$ for fasting insulin; $r = 0.06$, $P = 0.08$ for 2-h insulin). By design, few women had NIDDM; 0.5% had fasting glucose levels of ≥140 mg/dl, and 2.8% had 2-h glucose levels of ≥200 mg/dl. As shown in Fig. 1, insulin levels increased in parallel with glucose levels until postchallenge glucose levels exceeded 200 mg/dl.

Age-adjusted covariates of glucose and insulin

Tables 1 and 2 show the age-adjusted fasting and 2-h glucose and insulin levels for all women by sociodemographic characteristics (education level, ethnicity/race, and family income) and BMI and WHR

Table 1—*Age-adjusted mean fasting and 2-h glucose and insulin levels for sociodemographic, obesity, and fat-distribution factors*

	n	Fasting glucose (mg/dl)	2-h glucose (mg/dl)	Fasting insulin (pmol/l)	2-h insulin (pmol/l)
Education					
Grade school	25	99.4 ± 9.8	129.5 ± 41.7	35.4 ± 28.0	370.2 ± 285.4
High school graduate	481	97.6 ± 9.3	116.3 ± 35.9	37.9 ± 28.4	326.2 ± 265.1
College graduate	222	96.4 ± 10.6	109.0 ± 35.1	32.9 ± 25.2	308.9 ± 215.8
Postcollege graduate	135	96.4 ± 9.4	111.1 ± 34.8	30.7 ± 27.1	260.5 ± 232.8
P		0.06	0.0006	0.003	0.003
Ethnicity/race					
Black	32	99.2 ± 11.1	116.7 ± 29.1	54.4 ± 46.5	458.4 ± 334.8
Hispanic	44	99.4 ± 10.0	132.4 ± 40.7	51.9 ± 31.4	511.2 ± 361.5
Other	19	100.0 ± 10.8	121.0 ± 33.5	31.1 ± 25.5	379.2 ± 204.5
Non-Hispanic white	768	96.9 ± 9.6	112.6 ± 35.7	34.0 ± 26.0	296.7 ± 237.2
P		0.11	0.003	<0.0001	<0.0001
Family income					
<$20,000	91	99.6 ± 14.5	123.4 ± 48.4	36.6 ± 28.4	300.9 ± 230.6
$20,000–$49,999	365	97.7 ± 9.4	114.9 ± 34.2	36.1 ± 27.8	319.4 ± 267.0
$50,000–$74,999	300	96.1 ± 9.0	111.5 ± 32.8	34.4 ± 27.8	307.1 ± 231.8
≥$75,000	88	96.6 ± 7.0	109.8 ± 32.8	33.8 ± 25.5	312.0 ± 268.5
P		0.005	0.0006	0.32	0.93
BMI					
1st <23.52	288	94.1 ± 7.8	104.6 ± 30.9	25.7 ± 16.6	230.4 ± 161.0
2nd 23.52–27.23	288	96.5 ± 9.0	111.1 ± 29.7	30.1 ± 20.5	303.6 ± 209.5
3rd >27.23	287	100.8 ± 10.8	126.1 ± 42.3	56.4 ± 43.7	431.0 ± 375.4
P		0.0001	<0.0001	<0.0001	<0.0001
WHR					
1st <0.759	288	94.1 ± 7.2	103.4 ± 27.9	25.5 ± 16.3	239.7 ± 168.0
2nd 0.759–0.811	288	96.2 ± 9.0	110.6 ± 31.7	33.4 ± 24.4	288.2 ± 224.5
3rd >0.811	287	101.2 ± 11.1	127.9 ± 42.2	51.8 ± 41.1	439.0 ± 349.1
P		<0.0001	<0.0001	<0.0001	<0.0001

Data are means ± SD.

(Table 1); lifestyle characteristics (alcohol use, activity level, and smoking status); and reproductive/menopause history, hysterectomy status, and prior use of contraceptive and noncontraceptive estrogen (Table 2). *P* values are from analyses of covariance.

As shown, mean levels of fasting and postchallenge insulin and glucose increased significantly with increasing BMI and WHR. African-American (n = 32) and Hispanic (n = 47) participants, who tended to have higher BMI and more central obesity, had higher glucose and insulin levels than non-Hispanic white (n = 775) women. Lower attained education levels were associated with higher levels of fasting and postchallenge glucose and insulin. Lower family incomes were associated with significantly higher levels of glucose but not insulin. Alcohol use was inversely associated with insulin levels. Increasing levels of reported activity were associated with lower glucose and postchallenge insulin levels. Former and current smokers had slightly lower levels of postchallenge glucose than subjects who were never smokers. Increasing parity was associated with higher fasting and postchallenge insulin levels.

Multiply adjusted covariates of glucose and insulin

Figure 2 shows that in age-adjusted comparisons, each increasing tertile of BMI and WHR was independently associated with a significant increment in fasting and postchallenge glucose and insulin levels. In multivariable models (Table 3), BMI and WHR were by far the most important predictors of fasting and postchallenge glucose and insulin concentrations. Together they accounted for ~18% of the variability in fasting glucose, 16% in postchallenge glucose, 28% in fasting insulin, and 17% in postchallenge insulin, while age and other covariates explained at most an additional 6%. Ethnicity was predictive of both fasting and 2-h insulin levels independent of BMI and WHR. Adjusted mean fasting and 2-h insulin levels were higher for African-Americans (42.1 ± 5.1 pmol/l, 378.2 ± 49.3 pmol/l) and Hispanics (45.1 ± 4.6 pmol/l, 450.5 ± 49.6 pmol/l) compared with non-Hispanic whites (34.7 ± 0.8 pmol/l, 301.4 ± 7.9 pmol/l). The only other extrinsic factor independently associated with insulin level was a significant positive correlation between past estrogen replacement therapy and postchallenge insulin.

After controlling for age, BMI, and WHR, alcohol use was positively and independently associated with fasting glucose (Table 3). Adjusted means ± SE from the regression model were 96.3 ± 0.7 mg/dl (never drinkers), 97.1 ± 0.8 mg/dl (former drinkers), 96.9 ± 0.4 mg/dl (<1 drink per day), and 98.9 ± 0.8 mg/dl (≥1 drink per day). Increased physical activity had a modest association

Table 2—*Age-adjusted mean fasting and 2-h glucose and insulin levels for reproductive, menopausal, prior-hormone-use, and lifestyle factors*

	n	Fasting glucose (mg/dl)	2-h glucose (mg/dl)	Fasting insulin (pmol/l)	2-h insulin (pmol/l)
Age at menopause					
40–49 years	194	97.4 ± 8.3	113.4 ± 33.1	37.1 ± 28.3	309.1 ± 248.5
≥50 years	396	96.8 ± 10.0	111.9 ± 37.8	33.9 ± 25.4	293.5 ± 238.8
P		0.50	0.63	0.30	0.47
Hysterectomy status					
Uterus present	278	97.3 ± 10.2	117.2 ± 34.7	37.9 ± 28.4	301.1 ± 249.8
Uterus absent	585	97.1 ± 9.5	112.4 ± 36.4	34.9 ± 26.7	321.5 ± 249.3
P		0.70	0.07	0.67	0.23
Parity					
None	116	97.3 ± 10.6	110.9 ± 34.2	30.6 ± 25.2	272.7 ± 231.4
1	70	95.7 ± 6.7	112.3 ± 30.8	33.6 ± 28.2	286.4 ± 207.6
2	206	97.5 ± 10.3	113.1 ± 39.5	34.4 ± 28.3	305.7 ± 250.3
3	211	96.7 ± 8.6	113.5 ± 31.0	35.4 ± 26.4	331.6 ± 259.9
4+	260	97.7 ± 10.3	116.8 ± 38.6	38.8 ± 29.5	327.4 ± 259.0
P		0.50	0.12	0.005	0.02
Prior estrogen replacement therapy					
No	406	97.6 ± 10.4	113.1 ± 57.7	35.7 ± 28.4	301.1 ± 249.8
Yes	457	96.8 ± 9.1	114.7 ± 34.2	34.9 ± 26.7	321.5 ± 249.3
P		0.23	0.52	0.67	0.23
Alcohol use					
Never	154	96.5 ± 10.7	115.6 ± 35.0	38.0 ± 32.0	338.2 ± 271.0
Former	117	97.8 ± 9.7	114.0 ± 34.2	37.7 ± 28.9	338.7 ± 310.0
<1 per day	440	96.8 ± 9.3	113.8 ± 36.6	35.0 ± 26.9	308.6 ± 233.1
≥1 per day	145	98.4 ± 9.6	112.7 ± 36.4	31.5 ± 23.8	272.8 ± 224.3
P		0.25	0.49	0.03	0.01
Activity level					
Low	309	98.2 ± 10.7	118.6 ± 41.1	36.0 ± 29.3	340.9 ± 287.5
Medium	346	97.5 ± 9.6	111.9 ± 32.1	35.6 ± 26.6	309.8 ± 235.6
High	207	95.1 ± 7.9	110.8 ± 35.7	33.9 ± 26.5	276.3 ± 217.0
P		0.0008	0.01	0.40	0.003
Smoking					
Never	424	96.9 ± 9.8	154.2 ± 41.9	36.0 ± 28.1	328.1 ± 254.0
Former	320	97.0 ± 9.8	146.2 ± 45.1	35.3 ± 28.6	301.2 ± 254.6
Current	117	98.2 ± 9.2	150.9 ± 47.2	32.9 ± 22.5	283.2 ± 209.4
P		0.043	0.05	0.53	0.13

Data are means ± SD.

with lower fasting glucose levels in addition to what could be explained by age, obesity, and WHR (Table 3). Adjusted mean fasting glucose levels were 97.3 ± 0.5 mg/dl (low activity), 97.7 ± 0.5 mg/dl (moderate activity), and 96.0 ± 0.6 mg/dl (high activity). Smoking was associated with lower levels of postchallenge glucose after controlling for age and BMI (Table 3). Adjusted mean 2-h glucose levels were 108.6 ± 3.2 mg/dl and 110.1 ± 1.9 mg/dl for current and former smokers compared with 118.2 ± 1.7 for subjects who were never smokers. In addition, low educational attainment continued to be associated with increased postchallenge glucose (Table 3). Fitted mean 2-h glucose levels were 129.6 ± 6.8 for women who were not high school graduates compared with 114.8 ± 6.8 mg/dl, 110.7 ± 2.3, and 113.0 ± 3.0 for high school, college, and postcollege graduates, respectively.

Although glucose concentrations were strongly associated with fasting and, in particular, postchallenge insulin levels, BMI and WHR continued to exhibit strong independent relationships ($P \leq 0.0001$) with insulin levels after controlling for glucose. Ethnic differences also persisted after adding glucose to the model.

CONCLUSIONS— Although it is well known that obesity, particularly central obesity, is associated with hyperinsulinemia and insulin resistance even when normal carbohydrate tolerance is maintained (4,5,20), there are only a few reported studies of insulin and glucose metabolism in postmenopausal women. In the PEPI women, BMI and WHR were each independently associated with fasting and postchallenge glucose and insulin levels and were the most important independent predictors in most models. BMI and WHR combined explained 18% of the variance in fasting glucose, 16% of the variance in 2-h glucose, 28% of the vari-

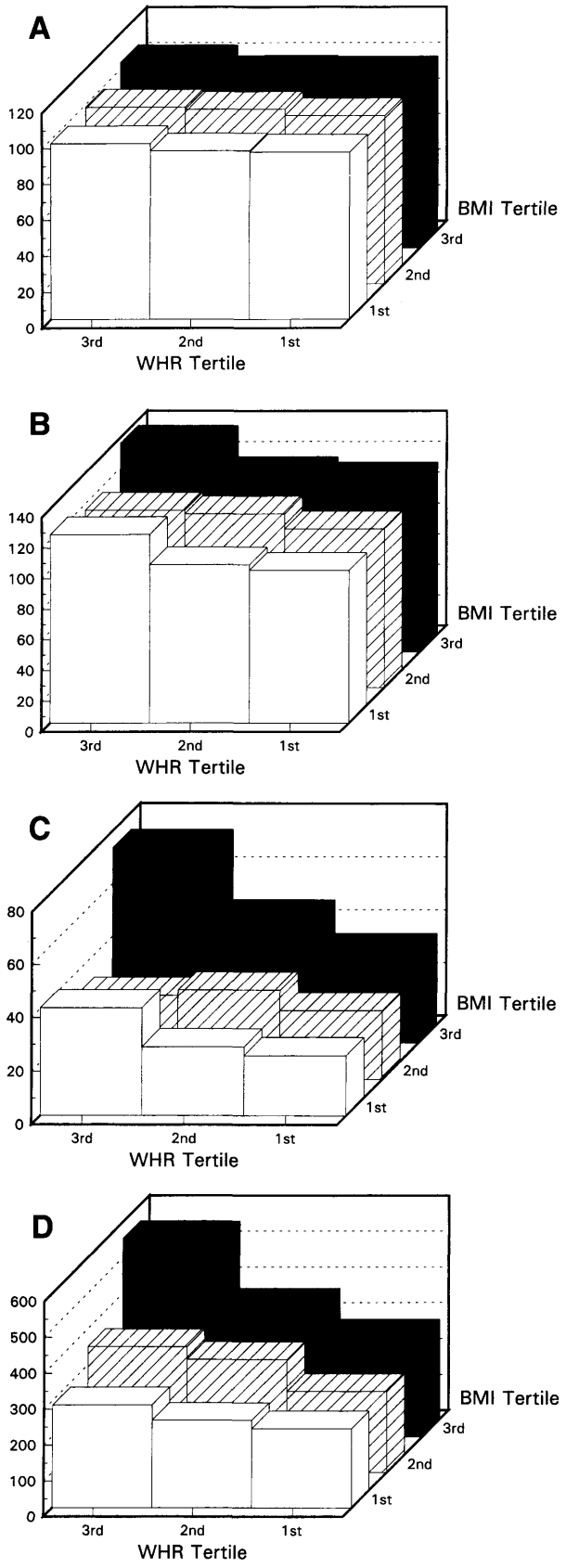

Figure 2—*Mean fasting (A) and 2-h (B) glucose and mean fasting (C) and 2-h (D) insulin by BMI and WHR.*

ance in fasting insulin, and 17% of the variance in 2-h insulin. Age and all other covariates explained <6% of the variance in glucose or insulin. These results are concordant with other studies showing that BMI and WHR were each independently associated with fasting and 2-h postchallenge insulin levels in older women (21–24).

Given that obesity and WHR are the most critical known determinants of glucose and insulin levels, the central question then becomes whether any other factors contribute to altered carbohydrate metabolism and insulin levels–independent of their association with overweight and fat distribution. In the PEPI women, several lifestyle factors related to obesity and central obesity, such as physical activity, alcohol intake, cigarette smoking, and parity, were associated with insulin and glucose levels when unadjusted for BMI and WHR, but the addition of these attributes to the obesity- and WHR-adjusted models contributed little additional information to the prediction of carbohydrate metabolism.

Considerable evidence, including small clinical trials (25–29), suggests that strenuous physical activity can reduce or prevent hyperinsulinemia. However, most studies failed to control for obesity, and even fewer described women. In New Zealand, women reporting regular heavy exercise had significantly lower insulin levels than sedentary women, but this association did not persist in a model adjusted for BMI, skinfold thickness, and glycemia (23). In Allegheny County women, higher reported activity levels were associated with lower 2-h insulin levels; this difference remained after adjusting for BMI, but not after adjusting for weight change (30). Failure to find an insulin–physical activity association independent of body size in this and other studies may reflect the fact that the effect is mediated by exercise-induced changes in obesity and fat distribution. If so, then adjusting for BMI and WHR in the present analysis underestimates the true effect of exercise. Reported physical activity may be particularly difficult to quantify in women, because their physical activity is more home and less sports related (31). In so far as exercise is misclassified, its effect would tend to be obscured by BMI and WHR, which can be measured more reliably. From a public health point of view, it does not matter whether exercise works

Table 3—*Multivariable associations of risk factors (all variables listed in Table 1) with fasting and 2-h glucose and insulin*

	Fasting glucose		2-h glucose		Fasting insulin		2-h insulin	
Predictors	*P* value	Partial R^2	*P* value	Partial R^2	*P* value	Partial R^2	*P* value	Partial R^2
Age	<0.0001	0.024	<0.0001	0.030	—	—	—	—
BMI	<0.0001	0.105	<0.0001	0.076	<0.0001	0.222	<0.0001	0.113
WHR	<0.0001	0.074	<0.0001	0.084	<0.0001	0.057	<0.0001	0.054
BMI * WHR	0.001	0.013	—	—	0.01	0.005	—	—
Ethnicity	—	—	—	—	0.01	0.009	0.002	0.014
Alcohol use	0.05	0.007	—	—	—	—	—	—
Activity level	0.07	0.005	—	—	—	—	—	—
Smoking	—	—	0.001	0.013	—	—	—	—
Education	—	—	0.04	0.008	—	—	—	—
Prior ERT	—	—	—	—	—	—	0.02	0.005
Others	—	0.014	—	0.012	—	0.014	—	0.023
Total	—	0.242	—	0.223	—	0.307	—	0.209

WHR includes both WHR and the square of WHR. BMI * WHR includes both the product of BMI with WHR and the product of BMI with the square of WHR. ERT, estrogen replacement therapy.

through an effect on obesity, muscle mass, or some other mechanism.

Alcohol intake and cigarette smoking were the only behaviors assessed in PEPI women that were independently associated with insulin or glucose levels. In regression models, women who smoke or drink alcohol tend to be leaner than nondrinking women and to have larger WHRs (32–34); this may be why some associations were more apparent after adjusting for obesity and fat distribution. The mechanism for the positive association of alcohol intake with fasting glucose levels, also reported in two other cross-sectional studies (35,36), is unknown. PEPI women with higher alcohol intake also had significantly lower fasting and 2-h insulin levels than nondrinkers, findings similar to those of a study of British women (37). However, the alcohol-insulin association in PEPI women was no longer present in models adjusted for obesity or WHR, compatible with the observation that alcohol may increase WHR (32).

Parity was not independently associated with glucose or insulin levels after adjusting for obesity and WHR, in contrast to some previous reports (38,39) but concordant with another study (40). None of the other factors associated with reproductive or menopausal history, except past use of noncontraceptive estrogen, were independent predictors of insulinemia or glycemia after adjusting for BMI and WHR, but this cross-sectional study would not be able to detect the increased insulin secretion and decreased insulin elimination reported in healthy estrogen-deficient postmenopausal women (41) or the transience of remote hormonal effects on insulin resistance (42,43). PEPI women were well beyond the age of discontinuing any oral contraceptive use, until recently proscribed for use after 40 years of age. The relevance of the weak independent estrogen-insulin association when estrogen had not been used for at least 3 months before the glucose tolerance test is uncertain; this association was only apparent after multivariable analysis.

In this large sample of postmenopausal women, most of whom were not obese, about two-thirds of the variance in glucose and insulin levels was unexplained. It is possible that more of the variance would be explained using more precise measures of obesity and fat distribution than BMI and WHR. Because women with uncontrolled hypertension, diabetes, or morbid obesity were excluded from the PEPI study, these observations do not necessarily apply to unrestricted population samples. Nevertheless, the higher insulin levels in African-Americans and Hispanics, independent of BMI, WHR, and family income, are similar to those in other reports (22,44,45). Further studies are necessary to delineate the role of ethnicity, genetics, and other factors that determine glucose tolerance in women.

Acknowledgments— The PEPI trial was supported by cooperative agreement research grants U01-HL40154, U01-HL40185, U01-HL40195, U01-HL40205, U01-HL40207, U01-HL40231, U01-HL40232, and U01-HL40273 from the National Heart, Lung, and Blood Institute; the National Institute of Child Health and Human Development; the National Institute of Arthritis and Musculoskeletal and Skin Diseases; the National Institute of Diabetes and Digestive and Kidney Diseases; and the National Institute on Aging.

APPENDIX— KEY PEPI PERSONNEL

Clinical Centers

George Washington University. Principal Investigator: Valery T. Miller, MD (Previously, John LaRosa, MD). Co-Investigators: Vanessa Barnabei, MD, PhD; Craig Kessler, MD. Key Personnel: Ginny Levin; Ann Smith-Roth; Margaret Griffin, RN, PA; Diane B. Stoy, RN, BS, PhD.

Johns Hopkins University. Principal Investigator: Trudy Bush, PhD. Co-Investigators: Howard Zacur, MD, PhD; David Foster, MD. Key Personnel: Jean Anderson, MD; Alice McKenzie, MS; Susan Miller, ScD.

Stanford University. Principal Investigator: Peter D. Wood, DSc. Co-Investigators: Marcia L. Stefanick, PhD; Robert Marcus, MD. Key Personnel: Allison Akana, PA; W. LeRoy Heinrichs, MD;

Charlene Kirchner, RD; Katherine O'Hanlan, MD; Melissa Ruyle.

University of California, Los Angeles. Principal Investigator: Howard L. Judd, MD. Co-Investigator: Gail Greendale, MD. Key Personnel: Richard Bayalos, MD; Kathy Lozano, RNP; Kathy Kawakami, RN.

University of California, San Diego. Principal Investigator: Elizabeth Barrett-Connor, MD. Co-Investigator: Robert Langer, MD. Key Personnel: Donna Kritz-Silverstein, PhD; Mary Lou Carrion-Petersen, RN; Carmela Cavero, RN.

University of Iowa. Principal Investigator: Helmut G. Schrott, MD. Co-Investigator: Susan R. Johnson, MD. Key Personnel: Deborah A. Feddersen, RN; Denise L. Krutzfeldt; Jo Ann Benda, MD.

The University of Texas Health Science Center, San Antonio. Principal Investigator: Carl Pauerstein, MD. Co-Investigator: José Trabal, MD. Key Personnel: Robert Schenken, MD; Michael P. Stern, MD; Mercedes Rodriguez-Sifuentes, RN; Carann Easton, RN.

Coordinating Center

The Bowman Gray School of Medicine. Principal Investigator: H. Bradley Wells, PhD. Co-Investigators: Mark Espeland, PhD; George Howard, DrPh; Robert Byington, PhD; Claudine Legault, PhD; Sally Shumaker, PhD. Key Personnel: Patricia Hogan, MS; Don Hire, BS; Carol Wasilauskas, MS; Margaret James, MS; Kathy Lane, BS; Tim Terrell, MS; Stephanie Reece, BS; June Pierce, AB; Mary Snow; Susan Anthony, BS.

Participating Institutes of the National Institutes of Health

National Heart, Lung, and Blood Institute. Program Administrator: Irma L. Mebane-Sims, PhD. Key Personnel: Paula Einhorn, MD; Sally Hunsberger, PhD; Myron Waclawiw, PhD (Previously, Ken Lippel, PhD; Diane Lucas, PhD; Joel Verter, PhD; Sherry Jackson, MD).

National Institute of Child Health and Human Development. Liaison: Joseph Kelaghan, MD (Previously, Jeffrey Perlman, MD; Pam Wolf, PhD).

National Institute of Arthritis and Musculoskeletal and Skin Diseases. Liaison: Joan McGowan, PhD (Previously, Stephen Gordon, PhD; Stephen Heyse, MD).

National Institute of Diabetes and Digestive and Kidney Diseases. Liaison: Judith Fradkin, MD.

National Institute on Aging. Liaison: Sherry Sherman, PhD (Previously, Lot Page, MD; Ann Sorenson, PhD).

Data and Safety Monitoring Board

Chairperson: Barbara Hulka, MD. Members: Baruch Brody, PhD; Ronald Burkman, MD; Robert Heaney, MD; Ronald Krauss, MD; Harold Roberts, MD; Janet Wittes, PhD (Previously, Lawrence Riggs, MD).

Central Facilities

Drug Distribution Center. Public Health Services, Health Resources and Services Administration, Supply Service Center: Cpt. Richard Moss

Lipid Laboratory. Northwest Lipid Research Center: John Albers, PhD; Santica Marcovina, PhD.

Glucose/Insulin Laboratory. Wishard Memorial Hospital: S. Edwin Fineberg, PhD.

Hemostasis Laboratory. University of Vermont: Russell P. Tracy, PhD.

Pathology Laboratory. National Cancer Institute: Maria Merino, MD.

Pathology Arbiter. Robert Scully, MD; Massachusetts General Hospital (Previously, Virginia Livolsi, MD).

Laboratory Consultant. Gerald Kessler, PhD; The Jewish Hospital of St. Louis.

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