Psychosocial Factors and Risk of Hypertension
The Coronary Artery Risk Development in Young Adults (CARDIA) Study

Lijing L. Yan, PhD, MPH
Kiang Liu, PhD
Karen A. Matthews, PhD
Martha L. Daviglus, MD, PhD
T. Freeman Ferguson, MPH, MSPH
Catarina I. Kiefe, MD, PhD

HYPERTENSION HAS LONG BEEN established as a strong, independent, and etiologically significant risk factor for cardiovascular disease.1 Despite progress in prevention, treatment, and control of high blood pressure, hypertension remains a major public health challenge.2 According to the National Health and Nutrition Examination Survey III (1988-1994), an estimated 43 million US adults aged 18 years or older were hypertensive (systolic blood pressure ≥ 140 mm Hg, diastolic blood pressure ≥ 90 mm Hg, or taking antihypertensive medication).3 The prevalence of hypertension increases sharply with age from approximately 3% among 18- to 24-year-olds to 13% among 35- to 44-year-olds and to 70% among those aged 75 years or older.4 However, studies on development of hypertension during a critical period in life—from young adulthood to early middle age—have been limited.

The role of psychosocial factors, such as the type A behavior pattern, depressive symptoms (depression), and anxiety, in the etiology of hypertension is supported by many epidemiological investigations.5-18 However, further studies are warranted because inconsistent results (negative or no associations between such factors and the risk of hypertension) have also been reported.19-24 Typically, psychosocial risk factors are studied individually, but...
many of these psychosocial characteristics are highly correlated.5,25,26 On the other hand, conflicting results regarding risk of coronary heart disease related to the type A behavior pattern, which is a multidimensional construct and one of the most extensively examined psychosocial factors, led to the hypothesis that different components of the type A behavior pattern may have differential health risks.27,29

Using the Coronary Artery Risk Development in Young Adults (CARDIA) study, we systematically and prospectively investigated the relationships of the 3 main components of the type A behavior pattern—hostile attitudes (hostility), time urgency/impatience (TUI), and achievement striving/competitiveness (ASC)—and 2 other major psychosocial factors, depression and anxiety, with long-term risk of developing hypertension.

**METHODS**

CARDIA is a multicenter, longitudinal study of the development of coronary artery disease risk factors in young adults. Details of the study design are published elsewhere.30 Briefly, the cohort includes 5115 black and white adults (51% of eligible persons contacted) aged 18 to 30 years at year 0 (1985-1986) recruited from 4 metropolitan areas (Birmingham, Ala; Chicago, Ill; Minneapolis, Minn; and Oakland, Calif). Within each center, the sample was designed to comprise approximately equal numbers of participants by sex, race (self-defined: black or white), age (18-24 or 25-30 years), and education (≤high school or >high school). Five follow-up examinations have been conducted at years 2, 5, 7, 10, and 15 (2000-2001). All examinations were approved by institutional review boards at each institution, and informed consent was obtained from each study participant.

**Assessment of Psychosocial Factors**

The TUI and ASC components of type A behavior pattern were ascertained from the 10-item Framingham Type A Questionnaire19 collected at year 0. Accordingly to the coding scheme previously reported,31 TUI was measured by 4 items (feeling pressured for time in general, feeling pressured at the end of an average work or housework day, eating too quickly, and getting quite upset when having to wait for anything). These 4 items were summed into a rating scale for TUI, with a range of 0 to 6 points: 0 (low), 1 (medium-low), 2 (medium-high), and 3-4 (high). The group with a TUI score of 4 was combined with the score group of 3 because of small numbers. In a similar fashion, the ASC component was classified into 4 mutually exclusive categories on the basis of 4 other items in the Framingham Type A Questionnaire (having a strong need to excel in most things, being bossy or dominating, being hard driving and competitive, and thinking about work after working hours all day long).

Assessed at both years 0 and 5 (1990-1991), hostility was measured with the 50-item Cook-Medley Hostility subscale of the Minnesota Multiphasic Personality Inventory, which used a true-false format.32 This scale measures cynicism, hostile attribution, hostile affect, aggressive responding, social withdrawal, and other unspecified components of hostility. For these analyses, a total hostility score, ranging from 0 to 50, was used and categorized into approximate quartiles of the distribution. Data on depression and anxiety were not collected until year 5. The Center for Epidemiological Studies–Depression scale with 20 items and 4 response choices for each item was the instrument used to measure depression.33 This scale encompasses the major components of depressive symptoms (ie, depressed mood, feelings of guilt, worthlessness, helplessness, hopelessness, and sleep and appetite disturbance). Anxiety was measured by the Spielberger Trait Anxiety Inventory, also with 20 items and 4 response choices for each item.34 This instrument assesses the general tendency of experiencing anxiety (ie, unpleasant feelings of tension, apprehension, nervousness, and worry). In a way compatible with hostility, depression (scores ranging from 0 to 60) and anxiety (scores ranging from 20 to 80) were classified into approximate quartiles.

All 4 psychosocial instruments were self-administered and, with the exception of assessing ASC with 4 items in the 10-item Framingham Type A Questionnaire separately, have been previously used in population-based studies.5,9,10,31 For all 5 psychosocial variables, higher scores indicate higher tendency of a particular trait. Both the continuous (ordinal) and categorical versions of these variables were analyzed in relation to risk of hypertension.

**Definition of High Blood Pressure**

Hypertension was defined according to the criteria of the Joint National Committee 7: systolic blood pressure of 140 mm Hg or higher, diastolic blood pressure of 90 mm Hg or higher, or current use of antihypertensive medication.36 A Hawksley random zero sphygmomanometer was used to measure blood pressure. After a 5-minute rest, the right arm blood pressure of a seated participant was assessed at three 1-minute intervals. First- and fifth-phase Korotkoff sounds were recorded, and averages of the second and third measurements were used in all analyses.30 Trained interviewers obtained information on medication uses, including antihypertensive medications. Hypertension incidence was defined as the percentage of nonhypertensive participants at year 0 or year 5 who developed hypertension at 15-year follow-up.

**Baseline Covariates**

To correspond with the time of psychosocial measurements, baseline refers to year 0 for TUI, ASC, and year 0 hostility, and to year 5 for depression, anxiety, and year 5 hostility. Standard hypertension risk factors36,37 were included in the analyses to adjust for potential confounding and/or to assess the independent effect of psychosocial factors. Information on age, years of education completed, and weekly alcohol...
consumption (converted into milliliters per day) was collected by questionnaire. Medical history was administered by interviewers at year 0 but self-administered at year 5. Physical activity was assessed by a standard instrument, and energy expenditure for all moderate and vigorous activities was calculated in exercise units. Body mass index (BMI) was computed from measured height and weight as weight in kilograms divided by the square of height in meters.

**Exclusions**
Of the 5115 participants at baseline, 3672 (74% of the surviving cohort) were examined at 15-year follow-up. At the year 15 examination, pregnant women (n = 20) and participants without blood pressure data (n = 12) were excluded. The following exclusion criteria were maintained for both the year 0 and the year 5 sample. At year 0, 332 individuals were excluded for the following reasons: pregnancy (4), hypertension (98), history of myocardial infarction or angina (3), missing covariates (25), or missing TUI, ASC, or hostility (202). The final year 0 sample included 3308 individuals (90.1% of all year 15 participants); 636 black men, 897 black women, 833 white men, and 942 white women. The year 5 sample was composed of 3156 participants (1400 [44.4%] were black and 1761 [55.8%] were women). For the complete sample of nonpregnant, nonhypertensive individuals with data on all variables of interest at both years 0 and 5, the sample size was reduced to 2916. Individuals who were lost to follow-up or who had missing data were more likely to be black, male, younger, less educated, and smokers than participants in the study sample. Tendency of TUI or ASC did not differ between the 2 groups, but the former group was slightly more hostile, depressed, or anxious at time of assessment.

**Statistical Analyses**
The distribution of each of the 5 psychosocial factors (proportion within each of the 4 categories for each variable) was computed first. Given the ordinal nature of these variables, correlation among these factors was assessed with the use of Spearman rank order correlation. Baseline characteristics were compared across the 4 categories of each psychosocial variable and presented for the lowest and highest groups with significance tests by \( \chi^2 \) for categorical variables or unpaired 2-tailed \( t \) tests for continuous variables. Age-adjusted incidence rates by 4 psychosocial categories for the total sample and for each race and sex group were computed using general linear models with the binary variable of developing or not developing hypertension as the outcome, in which least square means of the binary outcome provided the percentages (incidence) of hypertension cases for each category, adjusting for the age distribution within each subsample. Multivariable logistic regression analyses were used to model the odds for developing hypertension at 15-year follow-up. Standard techniques were used to select models and to test for model validity (eg, goodness of fit, interactions, and collinearity). The final model included race, sex, baseline age, systolic blood pressure, education, BMI, physical activity, alcohol consumption, and 3 dummy variables, with the lowest category as the omitted reference group for each of the 5 psychosocial variables in separate models and additional models with simultaneous adjustment for all 5 psychosocial variables. Smoking was not included due to its inconsistent association with hypertension. Test for linear trend was performed with the continuous psychosocial variables in appropriate models (ie, general linear models for continuous outcomes and logistic regression for binary outcomes). All analyses were conducted using SAS statistical software (Version 8.02; SAS Institute Inc, Cary, NC).

**RESULTS**

**Distributions and Correlations of 5 Psychosocial Factors**
Of the 3308 participants in the year 0 sample, the distributions of TUI and ASC were similar in that the highest proportion of individuals had a score of 1 (medium-low category: 35.7% for TUI and 42.3% for ASC; Table 1), whereas the lowest proportion had affirmative answers for 3 or 4 of the 4 questions (high category: 15.0% for TUI and 10.9% for ASC). Because the quartile cut points for hostility (n = 3308), depression (n = 3156), and anxiety (n = 3156) were integer values, the 4 groups within each factor contained similar numbers of individuals. As shown in Table 1, these 5 psychosocial factors were correlated with most Spearman rank order correlation coefficients ranging from 0.16 to 0.31 (P < .001). The correlation between depression and anxiety was much higher (r = 0.71), whereas their correlations with ASC were much lower.

**Baseline Characteristics by Psychosocial Groups**
The mean age at the time of assessment was 25.1 years for TUI, ASC, and hostility and 30.1 years for depression and anxiety. At baseline (year 0), individuals with higher TUI scores were more likely to be women, white, and smokers and to have a more sedentary lifestyle and a lower mean systolic blood pressure (Table 2). On the other hand, higher proportions of men, blacks, more educated persons, and more physically active persons had a higher tendency of ASC. Men tended to score higher on hostility but lower on depression and anxiety than women. Other characteristics of individuals with higher degrees of hostility, depression, or anxiety were similar. Positive associations were observed between hostility, depression, and anxiety and black race, smoking, drinking alcohol, and BMI. Negative associations were observed between these 3 psychosocial factors and age, years of completed education, and physical activity (except for hostility).

**Age-Adjusted Incidence of Hypertension**
For the year 0 sample, the incidence of hypertension at year 15 was 15.0%...
Table 1. Measurements, Distributions, and Correlations of 5 Psychosocial Factors, the CARDIA Study, 1985-1991*

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Low</th>
<th>High</th>
<th>Low</th>
<th>High</th>
<th>Low</th>
<th>High</th>
<th>Low</th>
<th>High</th>
<th>Anxiety</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(n = 730)</td>
<td>(n = 497)</td>
<td>(n = 906)</td>
<td>(n = 359)</td>
<td>(n = 683)</td>
<td>(n = 710)</td>
<td>(n = 730)</td>
<td>(n = 772)</td>
<td>(n = 772)</td>
</tr>
<tr>
<td></td>
<td>Age group, y†</td>
<td>25-30</td>
<td>35-44</td>
<td>18-24</td>
<td>25-30</td>
<td>35-44</td>
<td>18-24</td>
<td>25-30</td>
<td>35-44</td>
</tr>
<tr>
<td></td>
<td>Current</td>
<td>SMOKING STATUS</td>
<td>11.7</td>
<td>15.5</td>
<td>14.7</td>
<td>12.5</td>
<td>16.0</td>
<td>11.4</td>
<td>16.4</td>
</tr>
<tr>
<td></td>
<td>Former</td>
<td>8.0 (14.8)</td>
<td>11.6 (27.7)</td>
<td>8.0 (14.8)</td>
<td>11.6 (27.7)</td>
<td>8.0 (14.8)</td>
<td>11.6 (27.7)</td>
<td>8.0 (14.8)</td>
<td>11.6 (27.7)</td>
</tr>
<tr>
<td></td>
<td>Alcohol consumption, mL/d</td>
<td>11.7 (25.3)</td>
<td>13.2 (19.9)</td>
<td>11.5 (23.8)</td>
<td>13.3 (21.2)</td>
<td>8.8 (15.3)</td>
<td>15.3 (26.9)</td>
<td>8.5 (15.8)</td>
<td>12.3 (29.8)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Systolic blood pressure, mm Hg</td>
<td>110.8 (10.3)</td>
<td>109.2 (10.6)</td>
<td>109.7 (10.3)</td>
<td>110.4 (10.4)</td>
<td>109.3 (10.1)</td>
<td>110.4 (10.5)</td>
<td>106.8 (8.7)</td>
<td>106.8 (8.7)</td>
</tr>
<tr>
<td></td>
<td>Diastolic blood pressure, mm Hg</td>
<td>68.6 (8.0)</td>
<td>67.7 (8.5)</td>
<td>67.9 (9.1)</td>
<td>67.9 (9.0)</td>
<td>68.6 (8.8)</td>
<td>68.1 (9.6)</td>
<td>68.4 (8.3)</td>
<td>68.6 (8.8)</td>
</tr>
</tbody>
</table>

Abbreviation: CARDIA, Coronary Artery Risk Development in Young Adults.

*Psychosocial factors of time urgency/impatience, achievement striving/competitiveness, and hostility were assessed at the first examination (1985-1986) at ages 18 to 30 years.

**Depression and anxiety were assessed at the third examination (1990-1991) at ages 23 to 35 years. Survey instruments appear in parentheses after each psychosocial factor.

†Year 0 age groups for all 5 psychosocial variables. Percentages may not total 100 due to rounding.

‡For the subsample with data on all 5 psychosocial factors.

$P < .05.

||P < .01.

§Participants with missing data were excluded.

¶Measured as weight in kilograms divided by the square of height in meters.

**Assessed using a standard instrument. Energy expenditure for all moderate and vigorous activities was calculated in exercise units.29

©2003 American Medical Association. All rights reserved.
overall, with 7.0% taking antihypertensive medication and 8.0% not taking medication but having a systolic blood pressure of 140 mm Hg or higher and/or a diastolic blood pressure of 90 mm Hg or higher. For the year 5 sample, the corresponding numbers were 13.6%, 5.9%, and 7.7%. For the cohort as a whole, there was a significantly graded positive relationship of TUI (P for trend = .001), hostility (P for trend = .047) with age-, race-, and sex-adjusted 15-year incidence of hypertension (FIGURE 1). For example, the adjusted hypertension incidence was 11.6% for individuals with TUI scores of 0 vs 18.4% for individuals with TUI scores of 3 or 4. In general, the observed patterns held true for the 4 race- and sex-specific groups, with stronger associations for white men than for other groups (FIGURE 2 and FIGURE 3).

Multivariable-Adjusted Risk of Hypertension

TABLE 3 presents the odds ratios (ORs) and 95% confidence intervals (CIs) of developing hypertension during the 10- or 15-year follow-up periods, adjusted for baseline (year 0 or year 5) hypertension risk factors and each of the 5 psychosocial factors separately for the total sample and the 4 race and sex groups. For the total sample, the association of TUI with risk of hypertension was positive, significant, and graded. Compared with the lowest score group, the 2 highest score groups had an OR of 1.47 (95% CI, 1.08-2.02) and 1.84 (95% CI, 1.29-2.62). This association was also found for hostility (OR, 1.38; 95% CI, 1.00-1.91) and (OR, 1.84; 95% CI, 1.33-2.54). The associations between TUI or hostility and hypertension were not as consistent for the 4 subgroups defined by race and sex, with P values for trends ranging from .04 to .19 for TUI and from .002 to .10 for hostility. Compared with the age-adjusted results (Figure 1 and Figure 3B), the relationship between depression and hypertension risk was attenuated so that no significant association was observed for any of the quartiles (ORs ranged from 1.23 [95% CI, 0.88-1.73] to 1.35 [95% CI, 0.94-1.92]; P for trend = .33). Participants in the highest ASC group had an elevated risk of hypertension (OR, 1.52; 95% CI, 1.06-2.18), but in subgroup analyses, this was only apparent among white men. No consistent patterns emerged from models relating to anxiety. Of note, estimates for white women were not as stable as those for other groups as indicated by the wide CIs, potentially due to small numbers of incident cases of hypertension in this group (eg, 5.0% overall for the year 0 sample).

Figure 1. Incidence of Hypertension for All Men and Women in the CARDIA Study, 1985-2001

The total sample was adjusted for age, race (indicator for black), and sex (indicator for male). P values for linear trend across 4 strata of the psychosocial variables were obtained from tests for the coefficients of the continuous version of these variables entered in logistic models. CARDIA indicates Coronary Artery Risk Development in Young Adults; TUI, time urgency/impatience; and ASC, achievement striving/competitiveness.

Figure 2. Age-Adjusted Incidence of Hypertension by Race and Sex Groups in the CARDIA Study

P values for linear trend across 4 strata of the psychosocial variables were obtained from tests for the coefficients of the continuous version of these variables entered in logistic models. CARDIA indicates Coronary Artery Risk Development in Young Adults.
We conducted additional analyses for the full sample of nonhypertensive individuals at both years 0 and 5 with data on all variables of interest (n=2916) and with adjustment for standard risk factors and all 5 psychosocial variables simultaneously. Table 4 displays the results of 4 such models, differing in the use of continuous vs categorical psychosocial variables, and of year 0 vs year 5 covariates for adjustment. Significant relationships were preserved in all 4 models for TUI and in the 2 continuous models for hostility. Relationships between nonpsychosocial risk factors and incident hypertension were in the expected directions and ranges of magnitude except that results for physical activity and alcohol consumption were not significant at the .05 level.

Supplemental Analyses

To maintain compatibility, we did not use race- and sex-specific quartile cut points for hostility, depression, or anxiety in the stratified analyses by race and sex reported herein. Additional analyses with race- and sex-specific cut points did not yield materially different results (data not shown). Due to the high correlation between depression and anxiety, we repeated the full model with only 4 psychosocial risk factors (without depression or without anxiety) and observed similar results (data not shown). We examined the 10-year hypertension risk associated with hostility quartiles assessed at year 5 (n=3118). The cut points were 1 to 3 points lower than year 0 hostility, suggesting that on average, hostility decreased with age. Compared with the lowest quartile, the unadjusted OR for quartile 2 was 1.39 (95% CI, 1.02-1.91); quartile 3, 1.84 (95% CI, 1.35-2.53); and quartile 4, 2.20 (95% CI, 1.61-3.00). After multivariable adjustment, compared with the lowest quartile, the OR for quartile 2 was 1.29 (95% CI, 0.92-1.81); quartile 3, 1.47 (95% CI, 1.04-2.08), and quartile 4, 1.28 (95% CI, 0.90-1.83).

The Center for Epidemiological Studies–Depression scale is often categorized into 3 depression score groups. In multivariable models for the full sample with adjustment for standard hypertension risk factors and depression (n=3156), the ORs (95% CIs) were 1.38 (1.06-1.79) for intermediate depression scores (8-15 points; n=1159) and 1.29 (0.96-1.74) for high depression scores (>16 points; n=710) compared with low depression scores (0-7 points; n=1287). Results did not differ substantially for blacks and whites. For ex-

**Figure 3.** Age-Adjusted Incidence of Hypertension by Race and Sex Groups in the CARDIA Study

<table>
<thead>
<tr>
<th>Category (Quartile)</th>
<th>Low (1)</th>
<th>Medium-Low (2)</th>
<th>Medium-High (3)</th>
<th>High (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hostility (Cook-Medley Hostility Subscale of the Minnesota Multiphasic Personality Inventory)</td>
<td><img src="image1.png" alt="Graph A" /></td>
<td><img src="image2.png" alt="Graph B" /></td>
<td><img src="image3.png" alt="Graph C" /></td>
<td></td>
</tr>
<tr>
<td>Depression (Center for Epidemiological Studies–Depression Scale)</td>
<td><img src="image4.png" alt="Graph D" /></td>
<td><img src="image5.png" alt="Graph E" /></td>
<td><img src="image6.png" alt="Graph F" /></td>
<td></td>
</tr>
</tbody>
</table>

Hostility was assessed at the first examination (1985-1986) at ages 18 to 30 years (15-year risk for hypertension). Depression was assessed at the third examination (1990-1991) at ages 23 to 35 years (10-year risk of hypertension). Anxiety was assessed at the third examination (1990-1991) at ages 23 to 35 years (10-year risk of hypertension). P values for linear trend across 4 strata of the psychosocial variables were obtained from tests for the coefficients of the continuous version of these variables entered in logistic models. CARDIA indicates Coronary Artery Risk Development in Young Adults.
ample, for high depression scores, the OR was 1.27 (95% CI, 0.89-1.83) for blacks and 1.48 (95% CI, 0.87-2.53) for whites. With an alternative definition of hypertension (systolic blood pressure >160 mm Hg, diastolic blood pressure >95 mm Hg, or taking antihypertensive medication), the multivariable-adjusted ORs for developing hypertension were 1.49 (95% CI, 1.09-2.02) for intermediate depression scores and 1.51 (95% CI, 1.07-2.13) for high depression scores. The positive relationship was much stronger among whites (n=1789) for both intermediate depression scores and high depression scores.

Table 3. Risk of Hypertension, Adjusted for Baseline Hypertension Risk Factors and Each of the Psychosocial Factors Separately, Total, and by Race-Sex Groups, the CARDIA Study, 1985-2001*

<table>
<thead>
<tr>
<th>Hypertension Risk, Odds Ratio (95% Confidence Interval)†</th>
<th>Black</th>
<th>White</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Men</td>
<td>Women</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15-Year Follow-up</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of participants/No. of cases</td>
<td>3308/497</td>
<td>636/146</td>
<td>897/202</td>
</tr>
<tr>
<td>Time urgency/impatience (Framingham Type A Questionnaire)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Score</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 (Low)</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>1 (Medium-low)</td>
<td>1.51</td>
<td>(1.12-2.03)</td>
<td>1.27</td>
</tr>
<tr>
<td>2 (Medium-high)</td>
<td>1.47</td>
<td>(1.08-2.02)</td>
<td>0.98</td>
</tr>
<tr>
<td>3-4 (High)</td>
<td>1.84</td>
<td>(1.29-2.62)</td>
<td>2.04</td>
</tr>
<tr>
<td>P for trend‡</td>
<td>.001</td>
<td>.09</td>
<td>.19</td>
</tr>
<tr>
<td>Achievement striving/competitiveness (Framingham Type A Questionnaire)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Score</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 (Low)</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>1 (Medium-low)</td>
<td>1.05</td>
<td>(0.81-1.37)</td>
<td>0.90</td>
</tr>
<tr>
<td>2 (Medium-high)</td>
<td>1.02</td>
<td>(0.75-1.40)</td>
<td>0.80</td>
</tr>
<tr>
<td>3-4 (High)</td>
<td>1.52</td>
<td>(1.06-2.18)</td>
<td>1.26</td>
</tr>
<tr>
<td>P for trend‡</td>
<td>.07</td>
<td>.71</td>
<td>.83</td>
</tr>
<tr>
<td>Hostility (Cook-Medley Hostility Scale)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quartile</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 (Low)</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>2 (Medium-low)</td>
<td>1.06</td>
<td>(0.76-1.47)</td>
<td>0.91</td>
</tr>
<tr>
<td>3 (Medium-high)</td>
<td>1.38</td>
<td>(1.00-1.91)</td>
<td>0.97</td>
</tr>
<tr>
<td>4 (High)</td>
<td>1.84</td>
<td>(1.33-2.54)</td>
<td>1.49</td>
</tr>
<tr>
<td>P for trend‡</td>
<td>&lt;.001</td>
<td>.10</td>
<td>.002</td>
</tr>
<tr>
<td>Depression (Center for Epidemiological Studies–Depression Scale)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quartile</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 (Low)</td>
<td>1.23</td>
<td>(0.88-1.73)</td>
<td>1.71</td>
</tr>
<tr>
<td>2 (Medium-low)</td>
<td>1.35</td>
<td>(0.94-1.92)</td>
<td>1.91</td>
</tr>
<tr>
<td>3 (Medium-high)</td>
<td>1.32</td>
<td>(0.92-1.90)</td>
<td>1.29</td>
</tr>
<tr>
<td>4 (High)</td>
<td>1.26</td>
<td>(0.90-1.78)</td>
<td>0.98</td>
</tr>
<tr>
<td>P for trend‡</td>
<td>.53</td>
<td>.77</td>
<td>.61</td>
</tr>
<tr>
<td>Anxiety (Spielberger Trait Anxiety Inventory)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quartile</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 (Low)</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>2 (Medium-low)</td>
<td>1.28</td>
<td>(0.92-1.78)</td>
<td>1.92</td>
</tr>
<tr>
<td>3 (Medium-high)</td>
<td>1.42</td>
<td>(1.02-1.99)</td>
<td>1.75</td>
</tr>
<tr>
<td>4 (High)</td>
<td>1.26</td>
<td>(0.90-1.78)</td>
<td>0.98</td>
</tr>
<tr>
<td>P for trend‡</td>
<td>.52</td>
<td>.22</td>
<td>.65</td>
</tr>
</tbody>
</table>

Abbreviation: CARDIA, Coronary Artery Risk Development in Young Adults.

*Each column represents 5 separate models, one for each psychosocial factor. All models include baseline (year 0 for the first 3 psychosocial factors, year 5 for the last 2 psychosocial factors) age (years), education (years completed), body mass index (kg/m²), physical activity (exercise units), alcohol consumption (mL/d), and systolic blood pressure (mm Hg). Models for the total sample also include race (black) and sex (male).

†Unless otherwise indicated.

‡Linear trend across the 4 strata of the psychosocial variables obtained from the significance tests for the coefficients of the continuous version of these variables entered in the same models.
Psychosocial factors

Odds ratios presented are those associated with the unit differences in parentheses for that risk factor.

‡ORs and 95% CIs for the highest group for the psychosocial variables (2 other dummy variables for the middle 2 groups also entered in the models but not shown here. The lowest ORs and 95% CIs associated with approximately 1-SD differences in the continuous versions of the psychosocial variables (1 score for time urgency/impatience and achievement striving/competitiveness and 9 scores for the other 3 variables).

Table 4. 10-Year Risk of Hypertension With Simultaneous Adjustments for All 5 Psychosocial Factors and Other Hypertension Risk Factors at Years 0 and 5, the CARDIA Study, 1985-2001

<table>
<thead>
<tr>
<th>Psychosocial factors</th>
<th>Continuous†</th>
<th>High‡</th>
<th>Continuous†</th>
<th>High‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time urgency/impatience</td>
<td>1.16 (1.03-1.30)</td>
<td>1.58 (1.04-2.41)</td>
<td>1.16 (1.03-1.31)</td>
<td>1.64 (1.07-2.51)</td>
</tr>
<tr>
<td>Achievement striving/competitiveness</td>
<td>1.03 (0.91-1.17)</td>
<td>1.29 (0.85-1.95)</td>
<td>1.04 (0.91-1.18)</td>
<td>1.30 (0.85-1.97)</td>
</tr>
<tr>
<td>Hostility</td>
<td>1.20 (1.04-1.38)</td>
<td>1.43 (0.98-2.10)</td>
<td>1.16 (1.00-1.34)</td>
<td>1.35 (0.91-2.00)</td>
</tr>
<tr>
<td>Depression</td>
<td>0.99 (0.82-1.20)</td>
<td>1.13 (0.71-1.82)</td>
<td>0.98 (0.81-1.19)</td>
<td>1.17 (0.72-1.90)</td>
</tr>
<tr>
<td>Anxiety</td>
<td>0.96 (0.81-1.13)</td>
<td>1.04 (0.66-1.63)</td>
<td>0.97 (0.82-1.14)</td>
<td>1.04 (0.65-1.64)</td>
</tr>
</tbody>
</table>

Other risk factors§

| Black race                                | 2.43 (1.86-3.16) | 2.42 (1.85-3.16) | 2.13 (1.63-2.78) | 2.13 (1.63-2.79) |
| Male sex                                  | 0.94 (0.71-1.24) | 0.94 (0.71-1.24) | 1.02 (0.77-1.34) | 1.02 (0.77-1.34) |
| Age (5 years)                              | 1.72 (1.44-2.05) | 1.72 (1.44-2.06) | 1.73 (1.45-2.06) | 1.74 (1.46-2.07) |
| Education (2 years)                        | 0.85 (0.75-0.95) | 0.85 (0.75-0.96) | 0.86 (0.77-0.96) | 0.86 (0.77-0.97) |
| Body mass index (3 kg/m²)                  | 1.21 (1.14-1.30) | 1.21 (1.13-1.30) | 1.22 (1.15-1.29) | 1.22 (1.15-1.29) |
| Physical activity (100 units)              | 0.96 (0.92-1.00) | 0.96 (0.92-1.00) | 0.96 (0.92-1.00) | 0.96 (0.92-1.00) |
| Alcohol consumption (5 mL/d)               | 0.99 (0.96-1.02) | 0.99 (0.96-1.02) | 0.97 (0.94-1.00) | 0.97 (0.94-1.00) |
| Systolic blood pressure (5 mm Hg)          | 1.43 (1.34-1.54) | 1.43 (1.34-1.53) | 1.49 (1.39-1.60) | 1.49 (1.39-1.59) |

Abbreviations: CARDIA, Coronary Artery Risk Development in Young Adults; CI, confidence interval; OR, odds ratio.

*Each column represents one model. Columns 2 and 3 include as covariates nonpsychosocial factors measured at year 0; the last 2 columns include these same variables measured at year 5. All models include all variables listed (the first 3 psychosocial variables from year 0 and the last 2 from year 5).

†ORs and 95% CIs associated with approximately 1-SD differences in the continuous versions of the psychosocial variables (1 score for time urgency/impatience and achievement striving/competitiveness and 9 scores for the other 3 variables).

‡ORs and 95% CIs for the highest group for the psychosocial variables (2 other dummy variables for the middle 2 groups also entered in the models but not shown here. The lowest group was the reference group).

§ODDS ratios presented are those associated with the unit differences in parentheses for that risk factor.
Depression and Anxiety

No independent association between depression or anxiety and 10-year incidence of hypertension was found in our cohort, although depression categorized into 3 groups was positively associated with very high blood pressure (systolic blood pressure >160 mm Hg, diastolic blood pressure >95 mm Hg, or taking antihypertensive medication), particularly among blacks. Findings from previous research on this topic have been inconsistent, with a positive relationship reported in some studies20,22,23 but not in others.20,22,23 A few studies12,14 observed mixed results for different subgroups defined by age, race, or sex in the same population. For example, Jonas et al22 reported multivariable-adjusted increased risk of hypertension incidence during a mean follow-up of 9 years for white adults aged 45 to 64 years and for black adults aged 25 to 64 years who had high depression or anxiety scores based on two 4-item scales from the General Well-Being Schedule. These associations, either unadjusted or multivariable adjusted, were not found for white adults aged 25 to 44 years. Similarly, a prospective study of CARDIA participants14 reported that depressive symptoms classified into low, intermediate, and high were predictive in blacks but not in whites of 5-year incidence (from year 5 to year 10) of hypertension (defined as systolic blood pressure >165 mm Hg, diastolic blood pressure of >95 mm Hg, or undergoing treatment). In the same study, with hypertension defined as systolic blood pressure of 140 mm Hg or higher, diastolic blood pressure of 90 mm Hg or higher, or receiving treatment for hypertension, no significant relationship was observed after multivariable adjustment except for blacks in the intermediate depression group.

Results for anxiety have also been mixed.12,15,16,23,24 A report from the Framingham Heart Study (497 white men and 626 white women) demonstrated that only middle-aged men (aged 45-59 years) with high levels of anxiety, measured by a 7-item tension scale, had an elevated risk of hypertension during 18 to 20 years of follow-up.16 This increased risk was not found in middle-aged women or older men or women (aged ≥60 years).

Psychosocial Factors and Hypertension

The inconsistency of findings across studies on the relationship of psychosocial factors with hypertension is likely due to differences in research designs, psychosocial measurements, outcome definitions, length of follow-up, and study populations across studies and intraindividual, interindividual, and interpopulation variability of psychosocial factors. Our prospective study design, relatively large sample size balanced on sex and ethnicity (black and white), standardized data collection and quality control, and systematic analyses of 5 psychosocial factors confer credibility to our results on the relationship between psychosocial factors and risk of developing hypertension from young adulthood to early middle age. The etiology of hypertension is multifactorial, involving genetic factors, biophysiological processes, daily experiences throughout life, interactions between psychosocial factors and stress-provoking environments, and behavioral choices, such as diet, exercise, and weight regulation.7 Psychosocial factors must be understood in this broader context as part of the risk profile of the individual.

The prospective relationship between psychosocial factors and risk of developing hypertension may be confounded or mediated by demographic, socioeconomic, and behavioral factors.47 In general, younger persons, blacks (except for TUI), women (except for ASC or hostility), and less educated individuals (except for TUI or ASC) reported higher levels of measured psychosocial attributes. However, we found that the higher risk of developing hypertension associated with higher scores of TUI and hostility was independent of known risk factors for hypertension. Adjusting for daily alcohol consumption, physical activity, and BMI only slightly attenuated the relationship between TUI and risk of hypertension. The attenuation appeared to be stronger for hostility and depression, suggesting higher correlations between these 2 behavior patterns and lifestyle factors.

Biologically, it is plausible that psychosocial factors may increase the risk of developing hypertension. Sympathetic nervous system stimulation from acute stress, leading to increased cardiac output, vasoconstriction, arterial pressure elevation, impaired endothelial function, and platelet activation has been suggested as one mechanism.20,47,50 It has also been proposed that hypercortisolism and endocrine dysfunction may be involved in these processes.47,51,52 However, it is not well established whether the higher reactivity and temporary dysfunction of short-term stress lead to hypertension in the long run. The complex physiological processes involved in the potential linkage between psychosocial factors and development of hypertension are not well understood. More rigorous studies on underlying pathophysiological mechanisms of health risks related to psychosocial factors are needed.

Potential Limitations

This study has several limitations. First, the 5 psychosocial factors were not measured at the same time, and for most, they were only measured once. Previous research has demonstrated that multiple assessment is superior to single assessment in evaluating the psychosocial risk of the individual. Similarly, blood pressure measurement was obtained at a single examination, which may not be as reliable as measurements obtained at different time points or from ambulatory blood pressure monitoring.32 Second, power may not be adequate to obtain precise race- and sex-specific risk estimates, especially for white women. Third, even though we included systematic adjustment for established hypertension risk factors, residual confounding from unmeasured variables is still a possibility. Finally, our cohort of urban young adults may not be representative of the general popu-


