An Epidemiological Study of Blood Pressure and Lipid Levels Among Marwaris of Calcutta, India

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ABSTRACT This population based study was conducted among the Marwaris of Calcutta, India. A total of 1,096 individuals from 151 randomly selected families were studied. Mean blood pressures were high. About 17% of the population was hypertensive, i.e., systolic blood pressure > 160 mm Hg and/or diastolic blood pressure > 95 mm Hg. The mean value of the ratio of total cholesterol to HDL cholesterol was 4.75. Comparison with a rural agricultural population showed that unadjusted blood pressure profiles differed significantly, but not when the profiles were adjusted for variation in concomitants (e.g., age, weight, fatness, etc.). It is hypothesized that the "intrinsic" blood pressure profiles of both populations are similar and that genes influencing physical variables (e.g., fatness) do not directly influence blood pressure.

Essential hypertension is a major public health burden in many countries. It is a predictor and one of the most prominent causal factors for premature mortality and morbidity due to myocardial infarction, stroke, and other cardiovascular problems. Even "mild" essential hypertension, conventionally in the range of 90 to 104 mm Hg diastolic, is viewed as a major contributor to this premature mortality (Labarthe, 1986). An understanding of how blood pressure is influenced by genetic and environmental factors is the key to understanding the role played by hypertension in cardiovascular complications. Blood pressure profiles and etiologic factors affecting blood pressure are different for traditional societies and Westernized/urbanized societies (Epstein and Eckhoff, 1967; Siervogel, 1983; Ward, 1983). Further, while some of the factors that contribute to increased blood pressure seem to cut across cultural patterns and geographic regions, there are certain factors that seem to be population-specific (Marmot, 1979; Ward, 1983).

Another set of variables that contribute to cardiovascular problems, especially coronary heart disease, are lipid levels in the blood. Atherosclerosis, characterized by the deposition of lipids in the intima of arteries, is the cause of most cases of coronary heart disease. In studies conducted during the last three or four decades, a variety of risk factors for atherosclerosis have been identified (MacCluer and Kammerer, 1991). These include increased serum lipid level, cigarette smoking, male gender, a sedentary lifestyle, a high fat and high cholesterol diet, hypertension, obesity, diabetes, and heredity (positive family history). The factors that lead to hypertension also influence lipid levels. It is not known how much of coronary risk associated with hypertension might be attributed to these concomitant metabolic abnormalities (such as, very low high-density lipoprotein [HDL] cholesterol), or how much coronary risk from mild essential hypertension would remain even without dyslipidemia (Williams et al., 1990).

In order to gain insight into factors that influence blood pressure in traditional rural populations in India, which are characterized by a diet rich in carbohydrates but poor in fats and proteins, low stress, high levels of physical activity, etc., genetic epidemiological studies in two occupational groups of West Bengal, India, were conducted in the same geographical region. One group was primarily engaged in fishing (Mukherjee

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et al., 1988; Byard et al., 1989) and the other group was primarily engaged in agriculture (Majumder et al., 1990). In both studies, mean blood pressure levels were low in comparison with rural populations of the West. The prevalence of hypertension was, consequently, also low, 1.5% (agriculturists) and 6% (fishermen). While environmental factors, such as education, smoking, tension, oral-contraceptive use, etc., had no significant effect on blood pressure values adjusted for age and anthropometry in the agricultural population, education and smoking had significant effects in the population of fishermen. Statistically significant familial aggregation of blood pressure was observed in both populations. The heritabilities of systolic and diastolic blood pressures were estimated to be 0.3 (Majumder et al., 1990). In the population of fishermen, common household environment was the significant determinant of familial aggregation (Byard et al., 1989).

To study the impact of a contrasting set of environmental factors, a study in a population residing in an urban setting was conducted. The objectives of the study were 1) to determine the blood pressure profile of a population living in an environment which contrasts considerably with the populations previously studied, 2) to compare the blood pressure profiles and factors influencing the blood pressure levels in this population with those obtained in the previous population studies, and 3) to investigate the relationship between blood pressure and lipid profiles.

MATERIALS AND METHODS

Population and families

The population group is the Marwari, who come from the western Indian state of Rajasthan. The families were sampled in Calcutta. They migrated to Calcutta from Rajasthan between 100 and 300 years ago. The Marwaris are traditionally traders. The major reason for their migration was that trade thrived better in Calcutta than in Rajasthan. Because of the uncertainties associated with trading as a profession, the Marwaris, especially adult males, are generally under high stress. (This assessment is based on close long-term interaction with the Marwari families.) Further, their level of physical activity is low. They are strict vegetarians, and generally consume hydrogenated and saturated fats and oils in large quantities. Although there is considerable variation in the economic status of the Marwaris of Calcutta, the families included in this study were of a similar economic level. Most families belonged to the upper middle to high economic stratum.

A total of 151 randomly selected Marwari families, nuclear (32 families) and extended (119 families), comprising 1,096 individuals, each $\geq$ 12 years of age, were screened during 1988–1990. The average number of members in each nuclear family was 3.65 and in each extended family was 8.23. The Marwaris do not practice consanguinity, and there was no evidence of consanguinity up to the second-cousin level in the sampled families.

Variables

Three consecutive blood pressure (systolic and diastolic) and pulse rate readings were taken on the left arm of each individual in the sitting position after a 10-minute rest, with an electronic digital instrument. Anthropometric dimensions included height, weight, and skinfold thicknesses (biceps, triceps, and subscapular). Height was measured with a standard anthropometer, weight was taken with a bathroom scale, and a Harpenden skinfold caliper was used to measure skinfold thicknesses. Standard landmarks and methodology were used (Weiner and Lourie, 1969). Most readings and measurements were taken by a single investigator. The following data were also collected for each individual: age, gender, educational level, occupation, tobacco consumption (smoking and chewing), alcohol intake, use of anti-hypertensive drugs, use of oral contraceptives, use of steroids, whether suffering from any major tension, and whether has suffered or is suffering from any major disease. For the variable education, the category 'self-taught' comprises those individuals who have had no formal education, but were sufficiently motivated to get themselves educated informally. It may be noted that major tension was a personal assessment of the respondent of immediate psychological stress and pertained to the fortnight preceding the date of the survey. Death, birth, and marriage of immediate family members, school and college examinations, and so forth, were cited by the investigator as events that could lead to major tension. Major disease was classified in several broad categories: vascular/circula-

TABLE 1. Categories and sample sizes for categorical/ordinal variables

Variable	Categories	Sample size
Education	Illiterate	60
	Primary school level	302
	Secondary school level	347
	Graduate level and above	323
	Self-educated	11
Occupation	Business	319
	White-collar job	76
	Student	156
	Housewife	442
	Retired from work	49
Marital status	Never married	269
	Currently married	804
	Widow/widower	19
Tobacco use	Non-user	763
	Heavy smoker	30
	Light smoker	43
	Heavy chewer	92
	Light chewer	114
Alcohol use	Non-drinker	983
	Drinker	52
Major tension	Currently suffering	126
	Currently not suffering	893
Anti-hypertensive drug use	User	101
	Non-user	915
Oral contraceptive use	User	31
	Non-user	322
Major disease	No major disease	786
	Vascular/circulatory disease	107

tory disease, renal disorder, diabetes, thyroid disorder, and 'other.' Assessment of major disease was made by a qualified medical practitioner, who accompanied the survey team, based on a physical examination of the respondent, medical records, and personal interview. Although information on each categorical/ordinal variable was collected in detail, to avoid vagaries of small sample sizes, some pooling was done for data analysis. The final categories, with sample sizes in parentheses, used in the analysis for the various categorical/ordinal variables are given in Table 1.

A sample of about 10 ml of blood was collected in EDTA from each respondent, normally within 2 days of the physical measurements and blood pressures. Each subject was in a fasting condition for about 12 hours prior to blood collection. Determination of levels of sugar and urea were done on whole blood, while separated serum was used for determination of levels of creatinine, total cholesterol, HDL cholesterol, and triglyceride. Determinations of sugar, urea, and creatinine levels were done in the Biochemistry Laboratory of the Indian Statistical Institute, Calcutta, using standard protocols (Wootton, 1964; Hyvarinen and Nikkila, 1962). Determination of levels of total cholesterol, HDL cholesterol, and triglycerides was done at the Biochemistry Laboratory of the S.S.K.M. Hospital, Calcutta, using a Toshiba autoanalyzer.

Statistical methodology

Since three readings were available for blood pressures and pulse rate on each individual, the following strategy was adopted to convert the three readings to one. The values of $D_1 = |R_1 - R_2|$, $D_2 = |R_1 - R_3|$, and $D_3 = |R_2 - R_3|$, where R_1, R_2, and R_3 denote the three readings on a variable, systolic or diastolic blood pressure or pulse rate, were first computed. Whether the minimum of D_1, D_2, and D_3 exceeded 9 was then checked. (The cut-off point of 9, albeit arbitrary, corresponded to approximately 1% of observations being discarded.) If this minimum did not exceed 9, then the arithmetic mean of the two readings corresponding to this minimum value of D_i was taken as the reading of the individual. If the minimum value of D_1, D_2, and D_3 exceeded 9, the reading was designated as missing. By this procedure, the numbers of imputed missing readings were 12, 23, and 14, respectively, for systolic blood pressure, diastolic blood pressure, and pulse rate. There was no clustering of imputed missing readings in families. Since measures of skewness and kurtosis were significant for the majority of the primary variables, logarithmic transformations were done. Further analyses were performed on the transformed variables.

To study the effects of categorical/ordinal secondary variables (e.g., education, occupation, usage of oral contraceptives, tobacco, alcohol, anti-hypertensive drugs, marital status, tension, disease, and gender) on the primary variables (systolic and diastolic blood pressures, sugar, urea, creatinine, total and HDL cholesterol, and triglycerides), the effects of those quantitative secondary variables (height, weight, biceps, triceps, and subscapular skinfold thicknesses, pulse rate, and age) that had significant effects on the primary variables were regressed out. Assessment of significance of effect of the secondary quantitative variables was done by treating this set of variables as a set of predictor variables for predicting the primary variables taken one at a time. A stepwise multiple regression algorithm was used. For each transformed primary variable, the predictors were taken as the set of quantitative secondary variables which included age, height, weight, biceps, triceps, and subscapular skinfold thicknesses, and pulse rate. To allow for nonlinear (polynomial) age trends, age^2, and age^3 were also included in the set of predictor variables. The stepwise procedure was continued iteratively for each transformed primary variable. Since the presence of approximate linear relationships among predictor variables, collinearity, can lead to unstable estimates of regression coefficients (Belsley et al., 1980), it is imperative to examine the existence of collinearity. An assessment of collinearity was made by computing condition indexes and variance proportions. None of the condition indexes exceeded 30 and none of the variance proportions exceeded 0.5, implying the absence of collinearity (Belsley et al., 1980). Further, since one or a few observations often influence estimates of regression coefficients and the goodness-of-fit of the regression, an effort was made to detect and remove such influential observations. Simultaneously with the stepwise multiple regression procedure, an assessment of influential observations (outliers) was made by computing standardized residuals and Cook's distance (Cook, 1977; Belsley et al., 1980). Observations for which the standardized residuals exceeded 2 and/or Cook's distance was significant at the 5% level (the cut-off point being determined from F-distributions with appropriate degrees of freedom) were declared as influential (Cook, 1977; Belsley et al., 1980). Influential observations detected at each stage were removed from analysis and the stepwise multiple regression analysis was repeated. This iterative procedure was continued until two successive stepwise regression procedures identified identical subsets of significant predictors with regression coefficients of similar magnitudes. Influential observations thus detected were excluded from subsequent analyses.

After deletion of influential observations and the identification of the significant multiple regression equation for each of the primary variables, residuals were computed to remove the effects of quantitative secondary variables. To study the effects of categorical secondary variables, one-way analyses of variance were performed.

The relationship among the two sets of primary variables {systolic blood pressure, diastolic blood pressure} and {sugar, urea, creatinine, total cholesterol, HDL cholesterol, triglyceride} was analyzed by canonical correlation procedures (Harris, 1975).

Comparisons of blood pressure distributions of the present population with those of the sedentary rural agricultural population of Digha were performed by the Kolmogorov-Smirnov two-sample test procedure (Conover, 1971). Comparisons of logarithmically transformed distributions of systolic and diastolic blood pressures were made separately for males and females. These comparisons were performed for both unadjusted and for adjusted variables.

RESULTS

Descriptive statistics

Figure 1 provides the mean ± SE values of the primary variables by gender and age group. For systolic blood pressure, means increase with age for both males and females. For diastolic blood pressure, however, the trend with age is irregular in males, while means increase until age 40 years and then remains constant in females. For sugar, there is an increasing trend with age in females and up to 50 years in males, after which there is a decrease. Mean levels of urea increase slightly with age in males, but the trend is irregular in females. The trend for creatinine is irregular for males, but is slightly increasing for females. For both total cholesterol and triglyceride, an increasing trend is observed in both sexes, but for males there is a reversal of the trend after about 50 years. For triglyceride, an initial decrease is observed among females. The mean value of HDL cholesterol shows a somewhat irregular trend with age for both sexes.

Table 2 provides the total sample sizes, mean values, and standard errors of the primary variables separately by sex. For systolic blood pressure, the mean value for males is about 10 mm Hg greater than for females. Similarly, for triglyceride, the mean value for males is about 10 mg/dl higher than for females. For all other primary variables, the mean values of males and females are roughly equal.

Transformation of variables

The coefficients of skewness and kurtosis for the majority of the primary variables

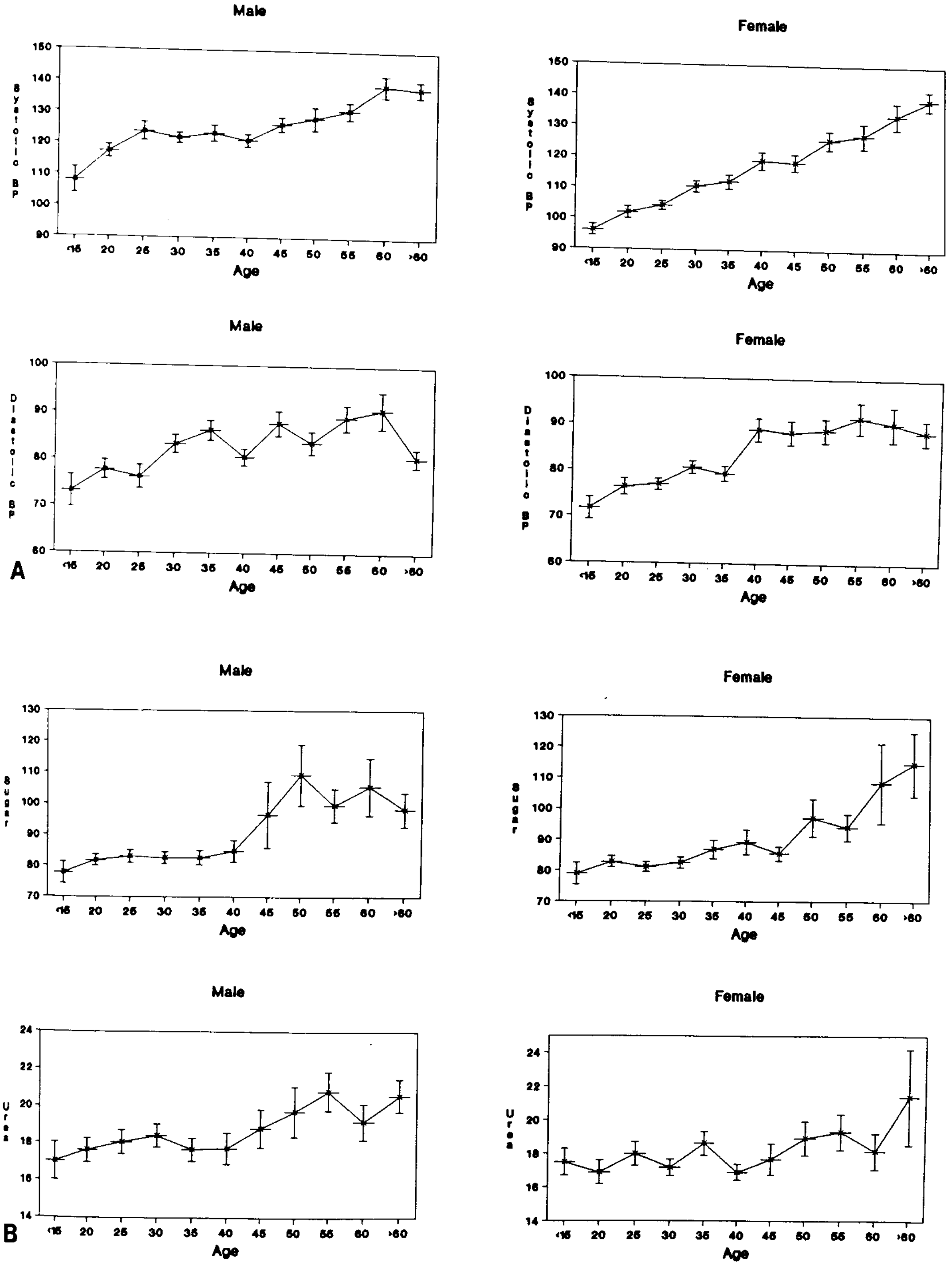

Fig. 1. A: Mean ± SE of systolic and diastolic blood pressure by age and gender B: Mean ± SE of sugar and urea by age and gender C: Mean ± SE of creatinine and total cholesterol by age and gender D: Mean ± SE of triglyceride and HDL cholesterol by age and gender.

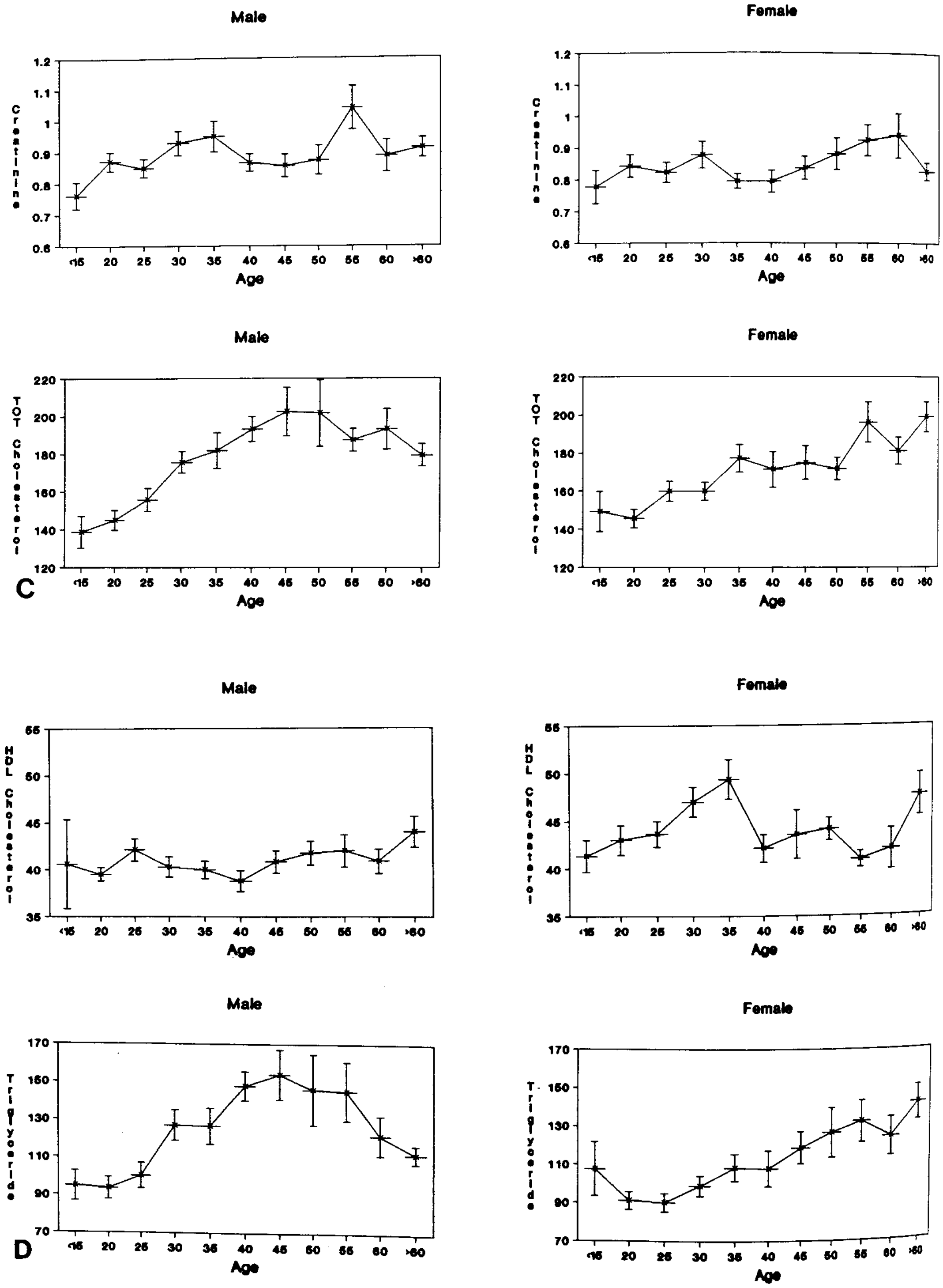

Fig. 1. (Continued.)

TABLE 2. Sample sizes, mean values, and standard errors of variables for males and females

	Male			Female		
Variable	n	Mean	SE	n	Mean	SE
Measurement						
SBP (mm Hg)	484	125.299	0.842	466	115.918	0.942
DBP (mm Hg)	480	82.282	0.745	458	83.192	0.710
Whole blood						
SU (mg/dl)	388	89.430	1.471	337	89.930	1.544
UR (mg/dl)	381	18.636	0.256	332	18.192	0.351
Serum						
CR (mg/dl)	351	0.899	0.013	305	0.845	0.012
TC (mg/dl)	353	176.864	2.607	306	171.180	2.344
HC (mg/dl)	219	41.064	0.418	180	44.250	0.533
TG (mg/dl)	349	122.957	2.976	305	110.816	2.619

SBP, systolic blood pressure; DBP, diastolic blood pressure; SU, sugar; UR, urea; CR, creatinine; TC, total cholesterol; HC, HDL cholesterol; TG, triglyceride.

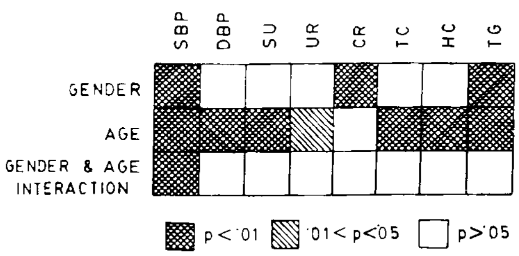

Fig. 2. Results of two-way analysis of variance to determine gender and age effects on blood pressures and lipid levels.

were large and significant at the 5% level. Substantial reductions in skewness and kurtosis were obtained by logarithmic transformations. Subsequent analyses were performed on the logarithmically transformed variables.

Age and gender differences

To investigate whether there are differences in mean values of the variables between genders and age groups, a two-way analysis of variance (ANOVA) was performed separately for each of the transformed variables. The results are summarized in Figure 2, from which it is seen that there are significant age effects for all variables, except creatinine. Gender differences in means are significant only for systolic blood pressure, creatinine, and triglyceride. Additionally, the interaction effect between gender and age group is significant only for systolic blood pressure.

Identification of influential observations and significant predictors of blood pressures and lipid levels

Table 3 presents the results of the iterative stepwise regression procedure. Convergence of the iterative procedure was achieved within four steps for all variables. Further, the number of influential observations deleted for the variables varied from four to ten; the total number of deleted observations for all variables was 52. Elimination of influential observations did not have any statistically significant effect on the population means. The table also shows that, with the exception of logarithmically transformed systolic blood pressure, the number of predictors that were significant from among the nine predictors varied from one to three. A significant non-linear trend with respect to age was found only for three logarithmically transformed variables, systolic blood pressure, total cholesterol, and triglyceride. Further, while the multiple R^2 of logarithmically transformed systolic and diastolic blood pressures with the significant predictors were high (0.34 and 0.43), the multiple R^2 values for the whole blood or the serum variables were all rather low (0.02–0.15).

Effects of categorical/ordinal variables on residuals

Effects of the significant quantitative predictor variables thus identified were then removed, and residuals were calculated. Analyses of variance were then performed to investigate the effects of qualitative categorical/ordinal variables on the residual values of the primary variables. The results of analyses of variance performed to test the

TABLE 3. Results of stepwise regression analysis performed iteratively to identify influential observations and significant predictor variables

Logarithmically transformed (ln) variable	Run no.	No. of influential observations deleted	Sample size	R^2	Regression equation	F ratio	d.f.
lnSBP	1	None	786	0.39	4.39 + .0057 (WT) + .0000006 (AGECUB)	246.53	(2,783)
	2	3	783	0.40	4.32 + .0059 (WT) + .0007 (PR) + .0000006 (AGECUB)	174.96	(3,779)
	3	4	779	0.43	4.30 + .0061 (WT) + .0007 (PR) + .0000006 (AGECUB)	192.63	(3,775)
lnDBP	1	None	776	0.32	4.06 + .0016 (AGE) − .0018 (HT) + .0045 (WT) + .0037 (BST) + .0015 (SST) + .0025 (PR)	59.17	(6,769)
	2	4	772	0.32	3.76 + .0018 (AGE) + .0035 (WT) + .0041 (BST) + .0020 (SST) + .0030 (PR)	73.27	(5,766)
	3	3	769	0.34	3.78 + .0018 (AGE) + .0033 (WT) + .0046 (BST) + .0022 (SST) + .0028 (PR)	77.96	(5,763)
lnSU	1	None	539	0.11	4.18 + .0044 (AGE) + .0019 (WT	32.23	(2,536)
	2	4	535	0.10	4.19 + .0040 (AGE) + .0017 (WT)	30.39	(2,532)
lnUR	1	None	533	0.05	2.79 + .0020 (WT) − .0061 (BST) + .0000004 (AGECUB)	9.84	(3,529)
	2	3	530	0.04	2.75 + .0019 (AGE) + .0018 (WT) − .0057 (BST)	6.92	(3,526)
	3	4	526	0.05	3.34 − .0041 (HT) + .0050 (WT) − .0099 (BST)	8.82	(3,522)
	4	3	523	0.05	3.34 − .0041 (HT) + .0050 (WT) − .0098 (BST)	9.29	(3,519)
lnCR	1	None	491	0.01	−.23 + .0017 (AGE)	6.95	(1,489)
	2	3	488	0.02	−.66 + .0026 (HT) + .0021 (BST)	5.23	(2,485)
	3	3	485	0.02	−.63 + .0024 (HT) + .0020 (BST)	4.84	(2,482)
lnTC	1	None	491	0.16	4.58 + .0173 (AGE) + .0027 (WT) − .000156 (AGESQ)	30.47	(3,487)
	2	4	487	0.15	4.60 + .0174 (AGE) + .0022 (WT) − .000159 (AGESQ)	29.26	(3,483)
lnHC	1	None	325	0.07	4.45 − .0044 (HT)	22.98	(1,323)
	2	3	322	0.08	4.34 − .0031 (HT) − .0017 (WT)	14.92	(2,319)
	3	3	319	0.06	4.36 − .0039 (HT)	21.97	(1,317)
	4	4	315	0.06	4.33 − .0038 (HT)	21.32	(1,313)
lnTG	1	None	490	0.14	3.76 + .0171 (AGE) + .0085 (WT) − .000156 (AGESQ)	27.39	(3,486)
	2	4	486	0.14	3.93 + .0040 (AGE) + .0094 (WT)	40.60	(2,483)
	3	4	482	0.15	3.92 + .0038 (AGE) + .0096 (WT)	42.48	(2,479)

SBP, systolic blood pressure; DBP, diastolic blood pressure; SU, sugar; UR, urea; CR, creatinine; TC, total cholesterol; HC, HDL cholesterol; TG, triglyceride; WT, weight; HT, height; BST, biceps skinfold thickness; TST, triceps skinfold thickness; SST, subscapular skinfold thickness; AGESQ, age squared; AGECUB, age cubed.

significance of differences in mean values of residuals of primary variables among individuals belonging to various categories of each of the categorical/ordinal variables are depicted in Figure 3. It is seen that two of the variables, alcohol use (primarily among males) and oral-contraceptive use among females, have no effect on residual values of any of the primary variables. Other categorical variables have significant effects on residual values of one or more of the primary variables.

Relationships among blood pressures and lipid levels

To quantify and understand the relationships among blood pressures and lipid levels, a canonical correlation analysis was performed (Table 4). The first pair of canonical variates appears to indicate that individuals with high levels of sugar and triglycerides have high blood pressures, both systolic and diastolic. The canonical correlation is 0.228. The second canonical correlation is small (about 0.1), but the corresponding canonical variate indicates that individuals with high HDL cholesterol have high values of systolic blood pressure, but low values of diastolic blood pressure.

Comparison of blood pressure profiles of Marwaris with a sedentary rural agricultural population

Comparisons of unadjusted and adjusted logarithmically transformed systolic and diastolic blood pressure distributions of the present population were made with those of a sedentary rural agricultural population studied earlier (Majumder et al., 1990). Comparisons were made separately for males and females. For the unadjusted logarithmically transformed systolic blood pressure the values of the Kolmogorov-Smirnov test statistics are 0.522 and 0.484 for males and females, respectively, and for logarithmically transformed diastolic blood pressure, the corresponding values are 0.617 and 0.484. All are significant at the 5% level.

Adjustments for the effects of secondary quantitative variables (age, height, weight, etc.) were made separately for males and females. These adjustments were made by

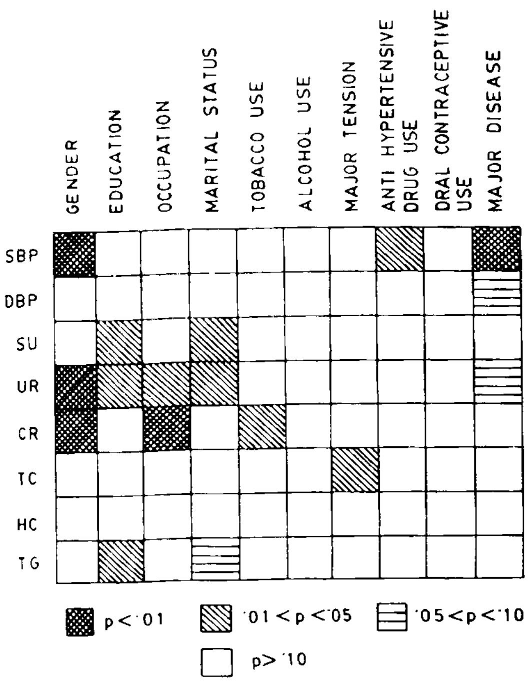

Fig. 3. Results of one-way analysis of variance to determine effects of environmental factors on adjusted blood pressures and lipid levels.

TABLE 4. Results of canonical correlation analysis to examine relationships among blood pressures and lipid levels

Variable	Coefficients of canonical variate 1	2
Set 1		
SBP	0.846	0.533
DBP	0.865	·0.502
Set 2		
SU	0.776	0.008
UR	0.082	0.062
CR	0.018	0.191
TC	0.165	0.363
HC	0.051	0.969
TG	0.582	0.029
Canonical correlation coefficient (R)	0.228	0.085

Abbreviations as in Table 2.

the procedures outlined previously, calculation of stepwise regressions, removal of influential observations, etc. The final regression lines obtained and used for computation of adjusted values of the primary quantitative variables (logarithmically transformed systolic and diastolic blood pressures) are given in Table 5. Different sets of concomitant variables are significant in the two populations. The reasons for this are unclear.

The distributions of the adjusted logarithmically transformed systolic and diastolic blood pressures between Marwaris and the Digha were compared separately for males and females. The values of the Kolmogorov-Smirnov test statistic for adjusted logarithmically transformed systolic blood pressure were 0.072 and 0.059 for males and females, respectively; for adjusted logarithmically transformed diastolic blood pressure, the corresponding values were 0.075 and 0.059. None of the values is significant at the 5% level.

DISCUSSION

The results of the analyses of data from Marwaris of Calcutta reveal several interesting features. Mean systolic and diastolic blood pressures among both males and females are much higher in this population than among the rural populations studied earlier (Mukherjee et al., 1988; Majumder et al., 1990). In fact, these values are even higher than those observed in a population-based sample from the United States (Perusse et al., 1991) or in a French-Canadian population (Perusse et al., 1989). The proportion of hypertensives (using the World Health Organization definition of 95 mm Hg diastolic or 160 mm Hg systolic) is about 17% compared with 1.5% and 6% found among the agricultural and fishing populations studied earlier.

On the other hand, the means of the lipid variables among the Marwaris are somewhat lower than the general white population in the United States (Reilly et al., 1991), and, in fact, are similar to those found among collegiate male athletes of the U.S. (Millard-Stafford and Sparling, 1992). It must be noted that mean HDL cholesterol is also lower in this population compared to the U.S. white population. The ratio of total cholesterol to HDL cholesterol is slightly greater among the Marwaris (4.75) than among U.S. whites (4.06). Since the total-to-HDL cholesterol ratio has been suggested as a more important indicator of coronary heart disease risk than either total cholesterol or HDL cholesterol alone (Gordon et al., 1977), it is apparent that the average Marwari is at a comparable or greater risk of

TABLE 5. Results of stepwise regression analysis for logarithmically transformed systolic (ln SBP) and diastolic (ln DBP) blood pressures among Marwaris and rural Bengali agriculturists

Population	Characteristic	Gender	Regression
Marwari	Urban (Calcutta), trader	Male	$\ln SBP = 4.37 + .004\,(WT) + .002\,(TST) + .001\,(PR) + .5 \times 10^{-6}\,(AGECUB)$
			$\ln DBP = 3.74 + .002\,(AGE) + .004\,(WT) + .010\,(BST) + .003\,(PR)$
		Female	$\ln SBP = 4.28 + .006\,(AGE) + .003\,(WT) + .003\,(TST)$
			$\ln DBP = 4.38 + .002\,(AGE) - .004\,(HT) + .005\,(WT) + .003\,(BST) + .002\,(PR)$
Bengali	Rural (Digha), agriculturist	Male	$\ln SBP = 4.89 - .003\,(AGE) - .004\,(HT) + .010\,(WT) + .8 \times 10^{-6}\,(AGECUB)$
			$\ln DBP = 3.25 + .013\,(AGE) + .006\,(WT) + .002\,(PR) - .1 \times 10^{-5}\,(AGECUB)$
		Female	$\ln SBP = 4.51 + .008\,(BST) + .6 \times 10^{-6}\,(AGECUB)$
			$\ln DBP = 3.45 + .011\,(AGE) + .010\,(BST) + .003\,(PR) - .9 \times -10^{-6}\,(AGECUB)$

Abbreviations as in Table 3.

TABLE 6. Relationships among adjusted means of primary variables for significant categorical/ordinal variables

Primary variable	Categorical/ordinal variable significant at the 5% level	Trend of mean adjusted values among classes
SBP	Gender	Male > Female
	Anti-hypertensive drug use	User > Non-user
	Major disease	Vascular/circulatory disease > No major disease
SU	Education	Illiterate > Secondary school level > Primary school level > Graduate level and above > Self-taught
	Marital status	Widow(er) > Never married > Currently married
UR	Gender	Female > Male
	Education	Illiterate > Primary school level > Secondary school level > Graduate and above > Self-taught
	Occupation	Housewife > Retired from work > Business > Student > White collar
	Marital status	Widow(er) > Currently married > Never married
CR	Gender	Male > Female
	Occupation	White collar > Business > Retired from work > Student > Housewife
	Tobacco use	Heavy smoker > Heavy chewer > Light chewer > Light smoker = Non-user
TC	Major tension	Currently not suffering > Currently suffering
TG	Education	Illiterate > Secondary school level > Primary school level > Graduate and above > Self-taught

Abbreviations as in Table 2.

developing coronary heart disease than the average U.S. white.

Age effects are significant for most variables; gender effects are less pronounced. The effects of many of the categorical/ordinal variables on the adjusted primary variables show some interesting trends (Table 6). For those primary variables for which the mean values among classes of categorical/ordinal variables showed statistically significant differences at the 5% level (Fig. 3), the trends of adjusted mean values of the primary variables are presented in Table 6. (The numerical values of adjusted means can be obtained from the authors.) Males have higher values of systolic blood pressure and creatinine than females; the reverse is true for urea. Users of anti-hypertensive drugs and those with vascular/circulatory disease have significantly higher systolic blood pressures. Both of these observations are in accord with expectations. Differences in individuals belonging to various education levels are significant for sugar, urea, and triglyceride. The trend in mean values among educational classes for each of these three variables shows that higher levels of education are correlated with lower levels of blood sugar, blood urea, and serum triglyceride. The self-taught group has the lowest mean value for these three primary variables compared with the other educational classes. This trend is presumably a reflection of better dietary intake which increases with level of education. While the trends in means for other primary variables are also interesting, the interpretations, are not clear. None of the categorical/ordinal variables has a significant effect on systolic and diastolic blood pressures in the rural popu-

TABLE 7. Comparison of means of primary variables between pairs of classes of categorical/ordinal variables for which significant differences were detected at the 5% level

Primary variable	Categorical ordinal variable	Classes compared	t value	d.f.
SU	Education	Illiterate vs. Secondary school level	2.604	240
		Illiterate vs. Primary school level	2.354	139
		Illiterate vs. Graduate level	3.141	262
	Marital status	Widow(er) vs. Currently married	2.172	523
		Widow(er) vs. Never married	2.707	163
UR	Education	Primary school level vs. Graduate level	2.599	412
		Secondary school level vs. Graduate level	2.006	432
	Occupation	Housewife vs. Business	2.605	492
		Housewife vs. Student	2.206	364
	Marital status	Widow(er) vs. Currently married	2.071	520
		Widow(er) vs. Never married	2.165	158
CR	Occupation	White collar vs. Housewife	3.974	292
		Business vs. Housewife	6.203	450
		Retired vs. Housewife	2.167	272
		Student vs. Housewife	3.452	337
	Tobacco use	Heavy smoker vs. Non-user	2.798	459
		Heavy smoker vs. Light chewer	2.178	88
		Heavy smoker vs. Light smoker	3.174	41
		Heavy chewer vs. Non-user	2.181	496
TG	Education	Illiterate vs. Graduate level and above	2.215	230
		Secondary school level vs. Graduate level and above	2.082	393

Results of only those comparisons which were significant at the 5% level are presented. Abbreviations as in Table 2.

lation (Majumder et al., 1990). For those categorical/ordinal variables with more than two classes which showed statistically significant differences (at the 5% level) in means of primary variables among classes, pairwise t-tests were performed. Significant values are presented in Table 7.

The results of the canonical correlation analysis indicate that increased levels of blood sugar and serum triglyceride are associated with increased blood pressures and that increased HDL cholesterol is associated with increased systolic blood pressure and decreased diastolic blood pressure. Since hypertension and high levels of serum triglycerides are both positively correlated with coronary heart disease risk, the first finding is easily understood, although the correlation between blood sugar and blood pressure is not so directly interpretable. Further, HDL cholesterol is known to be a protective factor for coronary heart disease. The second finding indicates that increase in diastolic blood pressure implies a low HDL cholesterol level. Thus, a high diastolic blood pressure, but not necessarily systolic blood pressure, may indicate an individual's predisposition to coronary heart disease in this sample.

While unadjusted blood pressure profiles are significantly different for the two populations, the adjusted profiles are not. This may suggest that blood pressures are significantly mediated by other physical variables such as weight, fatness, etc. The primary reason for the differences in blood pressure profiles of the two populations may be due to differences in these physical variables. (The Marwaris are generally heavier and fatter than the agriculturists.) It is hypothesized that the genetic factors that control these physical variables do not directly control blood pressures. Therefore, when the effects of such concomitant variables are removed, the blood pressure profiles do not show any significant differences. In other words, the intrinsic blood pressure profiles, i.e., the blood pressure profiles adjusted for variation in concomitant variables of both populations are similar; observed differences are due to effects of concomitant variables.

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