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BLOOD PRESSURE COMPONENTS AS PREDICTORS OF ISCHAEMIC HEART DISEASE MORTALITY IN THE WEST OF SCOTLAND

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ABSTRACT

The relative importance of systolic blood pressure (SBP) versus diastolic blood pressure (DBP) in predicting the risk of ischaemic heart disease (IHD) mortality is controversial. We have re-examined SBP compared to DBP and other combinations of SBP and DBP in predicting the risk of IHD mortality in a long-term cohort study of 10,541 men and women in the West of Scotland.

During a mean follow-up of 11.6 years, 1,616 deaths occurred, among which 553 (34%; 327 male, 181 female) were caused by IHD.

In a multiple logistic regression (MLR) model the predictive values of SBP, DBP, mean arterial pressure (MAP), mean arterial index (MAI), and pulse pressure (PP) were examined in relation to IHD mortality after adjustment for age, body mass index (BMI), casual blood glucose, serum cholesterol and cigarette smoking at entry. All blood pressure measures were associated with IHD mortality; in females the risk of IHD deaths was more strongly associated with SBP; in males SBP and DBP had similar predictive strength.

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INTRODUCTION

Blood pressure has been identified as perhaps the most universal contributor to all forms of cardiovascular disease (CVD) and one of the strongest predictors for the occurrence of IHD.[1-11] Although both SBP and DBP are recognized predictors of IHD risk,[8] whether SBP or DBP is more important as a risk factor for this disease still remains controversial.

The argument that DBP is the chief determinant of cardiovascular morbidity from hypertension has been based on physiological grounds. The cardiovascular hallmark of essential hypertension is an increase in peripheral resistance which is manifested chiefly by a rise in DBP.[12,13] This viewpoint, however, has been questioned and for IHD some epidemiological studies favour SBP,[1,3,5-10] although this is not a universal finding.[4,14,15]

It is possible that both components of the blood pressure contribute to the risk of IHD mortality. We have studied the predictive value of various combinations of SBP and DBP for future IHD mortality in a middle-aged cohort in the West of Scotland. This study also examines the possible interaction of IHD risk factors and the relative strength of SBP, DBP, and various combinations of SBP and DBP as predictors of death from IHD in males and females separately.

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SUBJECTS AND METHODS

Subjects

The population, sampling frame, and methods of the Midspan study have been reported in detail by Hawthorne et al.[16] and only those features which are particularly relevant to the present study are described here. The population of this cohort study comprised 10,541 (78% response rate) men and women in the towns of Renfrew and Paisley, Scotland, aged 45-46 years old. They accepted a single general health examination between 1972 and 1976; in this study they have been followed-up for mortality to January 1986.

General Health Examination

The baseline examination in 1972-76, included measurement of height and weight with the subject in indoor clothing and without shoes. Adiposity was expressed as BMI which was calculated as weight (Kg) divided by square of height (m). Blood samples were collected in the afternoon and evening. A 10 ml. casual sample of venous blood was taken without venous stasis and glucose was determined (using whole blood) by the measurement of oxygen consumption.[17] Serum cholesterol was determined by autoanalyzer.[18] SBP and DBP were measured seated using the London School of Hygiene and Tropical Medicine Sphygmomanometer,[19] with a bladder of 12 × 22 Cm. DBP was taken at the disappearance of the fifth Korotkoff sound. Observers had been trained to measure blood pressure using a special tape recording in order to reduce bias and observer variation.[20] Monthly mean blood pressures in each observer were compared with group means to ensure quality control. Cigarette smoking status was assessed by a standard questionnaire.[21]

Mortality and Follow-up

The population was flagged at the National Health Service Central Registry and deaths have been reported monthly. Causes of death have been classified using the Eighth Revision (1972 to 1978) and the Ninth Revision (after 1979) of the International Statistical Classification of Disease, Injuries and Cause of Death (ICD).[22] The ICD codes for IHD are the same in the 8th and the 9th revision. The comparability ratio, for the change of classification from the Eighth to Ninth Revision used in this analysis, was estimatd as 0.928 for IHD mortality by the Registrar General in Scotland.[23]

During a mean follow-up of 11.6 years (range 10-14), 1,616 (961 male and 655 female) deaths occurred, among which 553 (34.2%; 327 male and 181 female) were attributed to IHD (ICD-9/410-414). Deaths from causes other than IHD have been excluded from this analysis.

Analysis

The blood pressure variables examined in relation to IHD mortality in this study included: SBP, DBP, PP (SBP-DBP), MAP (2/3 DBP + 1/3 SBP) and MAI (1/3 DBP + 2/3 SBP).

As SBP and DBP and derived combinations of them differ in range and variance and also depend upon age and gender, they were transformed to give an age-gender-adjusted standardized normal deviate (SND) for each individual by subtracting the age-gender-specific mean and dividing by the age-gender-specific standard deviation as in the Whitehall Study.[24] For example, for a male in the 45-49 age group:

SND for SBP = observed SBP - mean SBP for males in 45-49 age group

standard deviation of SBP for males in 45-49 age group

The SND indicates the degree to which a person's pressure (whether SBP, DBP, MAP, MAI or PP) deviates from an age-specific mean in standard deviation units. These differences provide a direct method for comparing the power of these five measures of blood pressure to predict IHD mortality. If the hypothesis of no difference between the DBP and SBP and derived combinations of them in subjects dying of IHD is true, we would expect the average difference in those subjects to be close to zero. Significance was

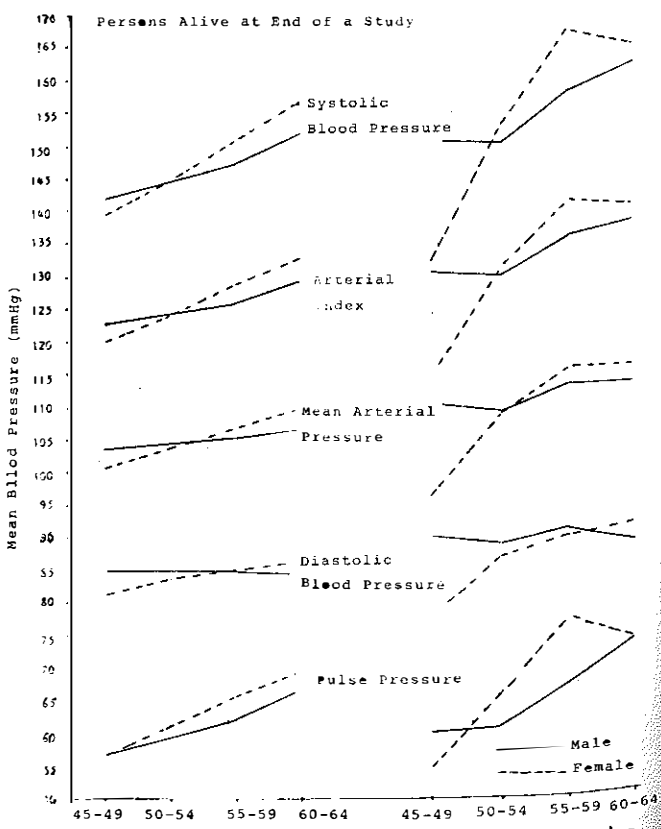

Fig 1. Average of SBP, DBP, MAP, MAI and PP at initial examination. Men and Women Aged 45-64 at Entry, Renfrew and Paisley, Scotland.

Table I. SBP, DBP, MAE and PP and Standardised Normal Deviate by Age Group, for Men Who Survive and Who Died of IHD After 10-14 Years of Follow-up. Men Aged 45-64 at Entry. Renfrew and Paisley, Scotland

Age (Yr)	Alive at End of Study			Died of IHD		
	No. of Cases	Mean (SD)	Standardized Normal Deviate (SD)	No. of Cases	Mean (SD)	Standardized Normal Deviate (SD)
			Systolic Blood Pressure			
45-49	1084	142.0(19.9)	−0.01(0.99)	34	150.8(21.4)*	0.43(1.06)
50-54	1063	144.8(21.2)	−0.03(0.98)	95	150.3(19.8)*	0.22(0.92)
55-59	904	147.1(21.8)	−0.08(1.01)	113	158.5(21.8)***	0.45(1.01)
60-64	743	151.9(22.5)	−0.09(0.95)	130	162.2(21.8)***	0.35(1.17)
			Diastolic Blood Pressure			
45-49	1084	85.2(12.8)	−0.01(0.99)	34	90.6(12.3)*	0.41(0.95)
50-54	1063	85.0(12.2)	−0.03(0.98)	95	89.3(12.3)**	0.29(0.98)
55-59	904	84.9(12.9)	−0.08(0.01)	113	113.7(15.3)***	0.47(0.95)
60-64	748	84.6(13.3)	−0.05(0.98)	130	113.3(16.7)***	0.34(1.09)
			Mean Arterial Pressure			
45-49	1084	104.1(14.1)	−0.0.01(0.99)	34	110.7(14.1)*	0.45(0.99)
50-54	1063	104.9(13.8)	−0.04(0.97)	95	109.6(13.3)**	0.29(0.94)
55-59	904	105.6(14.6)	−0.07(0.97)	113	113.7(15.3)***	0.47(0.95)
60-64	748	107.0(14.8)	−0.07(0.97)	130	113.3(16.7)***	0.34(1.09)
			Mean Arterial Index			
45-49	1084	123.1(16.6)	−0.01(0.99)	34	130.8(17.3)**	0.45(1.03)
50-54	1063	124.9(17.1)	−0.04(0.98)	95	130.0(16.0)**	0.26(0.92)
55-59	904	126.4(17.8)	−0.08(0.97)	113	136.1(17.5)***	0.46(0.96)
60-64	748	129.5(18.1)	−0.08(0.95)	130	137.8(21.8)***	0.35(1.14)
			Pulse Pressure			
45-49	1084	56.7(14.1)	0.00(0.99)	34	60.2(15.8)	0.24(1.15)
50-54	1063	59.8(16.3)	0.00(0.99)	95	61.0(15.8)	0.07(0.97)
55-59	904	62.2(16.1)	−0.06(0.96)	113	67.2(17.3)**	0.24(1.03)
60-64	748	67.3(17.4)	−0.0.07(0.95)	130	73.4(21.7)**	0.25(1.19)

*P<0.05, **P<0.01, ***P<0.001 (Comparing "deceased" with "survivor")

assessed by a paired T-test for the difference between each component of blood pressure and DBP and two sample T-test for the difference between blood pressure in persons who died compared to subjects who were still alive after 10-14 years.

To examine the contributions of each component of blood pressure, as well as calculating adjusted estimates of relative risk as the standardized odds ratio (SOR) to IHD mortality, MLR analysis (BMDP PLR)[25] was used to allow for confounding factors.[26] MLR analysis was undertaken to assess the relative contribution of each blood pressure variable to IHD mortality throughout the range of pressure recorded in the population sample.

Because of differences in the usual range of values for SBP, DBP, MAP, MAI, and PP and since the magnitude of the coefficients is affected by the variance of the characteristic, a direct comparison of the logistic function coefficients is not appropriate to determine the relative predictive strength of each blood pressure. In order to put all the coefficients on the same scale, the coefficient is multiplied by the standard deviation of the variable, and then exponentiated. This gives the odds ratio associated with a change of one standard deviation in the continuous variables of interest.[27]

RESULTS

Tables I and II and Fig. 1 present the effects of age and gender on blood pressure measurements. In survivors at follow-up the expected age-related gradient of SBP, MAI and PP at entry, was seen in each category for both males and females. This relationship is stronger for females than males. Females exhibit a lower average SBP, MAI and MAP below age 50-54, after which they overtake and exceed the pressure in males except for PP which was higher than males in all age groups. A smaller rise was also seen in females' DBP level and there was no rise with advancing age in men. Women have a higher mean DBP after age 60 years before which men have higher DBP. In persons who

Table II. SBP, DBP, MAP, MAI and PP Standardised Normal Deviate by Age Group, for Women Who Survived and Who Died of IHD After 10-14 Years of Follow-up. Women Aged 45-64 at Entry. Renfrew and Paisley, Scotland

Age (Yr)	Alive at End of Study			Died of IHD		
	No. of Cases	Mean (SD)	Standardized Normal Deviate (SD)	No. of cases	(SD)	Standardized Normal Deviate (SD)
			Systolic Blood Pressure			
45-49	1303	139.3(21.3)	−0.01(1.00)	11	132.6(17.0)	−0.23(0.33)
50-54	1420	144.9(22.9)	0.00(1.00)	31	153.2(24.0)*	0.36(1.05)
55-59	1263	151.0(25.0)	−0.05(0.97)	58	167.4(30.3)***	0.59(1.18)
60-64	1140	157.0(24.7)	−0.04(0.98)	81	165.1(25.5)***	0.29(1.01)
			Diastolic Blood Pressure			
45-49	1303	81.7(12.3)*	0.01(1.00)	11	78.2(8.1)	−0.28(0.66)
50-54	1420	83.6(12.5)	−0.01(1.00)	31	87.1(16.4)	0.27(1.30)
55-59	1263	85.1(13.2)	−0.021(0.97)	58	89.9(16.6)**	0.33(1.18)
60-64	1140	86.5(13.2)	−0.03(0.97)	81	91.6(12.5)***	0.33(0.90)
			Mean Arterial Pressure			
45-49	1303	100.9(14.0)*	0.00(1.00)	11	96.3(5.0)	−0.33(0.36)
50-54	1420	104.1(14.6)	0.00(0.99)	31	109.1(18.0)	0.34(1.22)
55-59	1263	107.1(15.7)	−0.04(0.98)	58	115.8(19.1)***	0.50(1.19)
60-64	1140	110.0(15.7)	−0.04(0.98)	81	116.1(14.9)***	0.34(0.93)
			Mean Arterial Index			
45-49	1303	120.1(17.3)**	0.00(1.00)	11	114.5(4.4)	−0.33(0.26)
50-54	1420	124.5(18.3)	0.00(1.00)	31	131.2(20.7)*	0.36(1.13)
55-59	1263	129.0(19.9)	−0.05(0.97)	58	141.6(24.2)***	0.56(1.18)
60-64	1140	133.5(19.2)	−0.04(0.98)	81	140.6(19.6)**	0.31(0.98)
			Pulse Pressure			
45-49	1303	57.6(15.7)	0.00(0.99)	11	54.4(12.5)	−0.21(0.79)
50-54	1420	61.3(17.1)	−0.01(1.01)	31	66.1(14.4)	0.29(0.85)
55-59	1263	65.8(18.7)	−0.05(0.96)	58	77.5(22.6)***	0.55(1.16)
60-64	1140	70.4(19.0)	−0.02(0.96)	81	73.5(21.1)	0.13(1.07)

*(<0.05 **P<0.01 ***P<0.001 (Comparing "deceased" with "survivor")

died from IHD the expected age-related gradients of SBP, MAP, MAI and PP levels at entry were seen in each age category for both males and females except for females aged 60-64 years. This association is stronger for females than males. In males who died from IHD there was no relationship between the DBP level and age. The mean SBP, DBP, MAP, MAI and PP levels, at entry, were widely separated in males and females in the younger age groups and closer, or crossed over at lower levels, in older males, except for PP which was higher in females in age groups 50-59. Overall the mean values for SBP, DBP, MAP and MAI were significantly greater for those dying of IHD than for survivors after 10-14 years follow-up, for all age groups in men and most age groups in women (Tables I, II).

The mean SND values showed a similar pattern to the blood pressure components but no consistent increase with advancing age. Table III also shows that the mean SND for SBP, DBP, MAP, MAI and PP were all significantly greater for those dying of IHD than for those still living at the time of follow-up. In both males and females dying of IHD, although the age-adjusted SND for SBP, MAP and MAI were slightly greater than that for DBP, the difference was not significant. In females the MAP deviate from the mean for their age-specific group is significantly different from their DBP.

Tables IV and V show the results of using the logistic model to predict IHD mortality. First, SBP, DBP, MAP, MAI and PP were studied separately as predictors of IHD mortality, without adjustment for the other main cardiovascular risk factors (Table IV). The logistic coefficients for SBP, DBP, MAP, MAI and PP each showed a strong relationship with IHD mortality in both genders. SBP and MAI had higher odds ratios than DBP, MAP and PP.

Table V contains the results of MLR analyses when both SBP and DBP are considered simultaneously and each of five blood pressure components separately, with adjustment for other confounding factors. In the first analysis using the MIR model, SBP and DBP, the PP, the MAP and the MAI were studied separately as predictors of IHD deaths for each gender. The logistic coefficients for the blood pressure measures were

Table III. Mean (SD) Standardised Normal Deviates for SBP, DBP, MAP, MAI and PP and Their Difference with DBP for 10-14 Years Mortality Outcome. Men and Women Aged 45-64 at Entry. Renfrew and Paisley, Scotland

No. of Cases	Male		Female	
	Alive at the End of Study	Died of IHD	Alive at the End of Study	Died of IHD
	3799	372	5126	181
(a) Blood Pressure Components				
SBP	−0.05(0.98)	0.35(1.05)***	−0.02(0.99)	0.36(1.06)***
DBP	−0.04(0.98)	0.33(0.99)***	−0.01(0.99)	0.28(1.06)***
MAP	−0.05(0.98)	0.37(1.00)***	−0.02(0.99)	0.35(1.06)***
MAI	−0.05(0.98)	0.37(1.02)***	−0.02(0.99)	0.36(1.06)***
PP	−0.03(0.98)	0.20(1.08)***	−0.02(0.98)	0.27(1.07)***
(b) Pairwise Differences Between Components				
SBP-DBP	−0.01(0.80)	0.02(0.89)	−0.01(0.80)	0.08(0.89)
MAP-DBP	−0.01(0.37)	0.04(0.42)	−0.01(0.39)*	0.07(0.45)*
MAI-DBP	−0.01(0.63)	0.03(0.70)	−0.01(0.64)	0.08(0.72)
PP-DBP	−0.01(1.32)	−0.13(1.40)	−0.01(1.27)	0.01(1.39)

In (a), two sample T-test was used to compare persons deceased with persons surviving at the end of study. In (b) paired T-test was used to compare the difference between the mean of each component of blood pressure and diastolic pressure. *P<0.05, **P<0.01, ***P<0.001.
Abbreviations: SBP=systolic blood pressure, DBP=diastolic blood pressure, MAP=mean arterial pressure, MAI=mean arterial index, PP=pulse pressure.

determined after adjustment for the effect of age, serum cholesterol, blood glucose, cigarette smoking and BMI on the IHD mortality. In comparison with the data in Table IV (which does not take into account the effect of associated factors) the SBP, DBP, MAP, MAI and PP contribute to IHD mortality risk independent of the other risk factors. Except for male DBP the SOR for SBP, PP, MAP and MAI decreased minimally after adjustment for other cardiovascular risk factors. A little of the effect is lost when other major risk fators are taken into account, judging from the modest reduction in the regression coefficient in the multivariate as compared to the univariate analysis. This reduction was higher in females than males. The magnitude of the SORs can give an indication of the relative contribution of each component.

Thus, although each of the five blood pressure measures was found to show a strong relationship to the risk of IHD after adjustment for other risk factors, further joint analysis of the SBP and DBP measures is required to determine which measure has the most power. The lower section of Table V also displays the results of multivariate analysis using the multiple risk model, in which SBP and DBP are considered together to determine their standardised predictive strength for the risk of IHD death in males and females. Although major changes were noted in the predictive strength of these adjusted factors compared to the results shown for SBP or DBP alone, the overall results are the same. In females, the DBP was not found to be significantly associated with IHD death. In males there is a statistically significant interaction between SBP and DBP.

Table IV. Univariate Logistic Coefficients and Odds Ratio of IHD Mortality on Various Components of Blood Pressure in 10-14 Years Follow-up, Men and Women Aged 45-64 at Entry. Renfrew and Paisley, Scotland

Blood Pressure Component	Male			Female		
	Logistic Coefficient§	Odds Ratio§§	Z-Test	Logistic Coefficient	Odds Ratio	Z-Test
SBP	0.020	1.62	8.9***	0.021	1.67	7.4***
DBP	0.027	1.42	6.7***	0.028	1.44	5.1***
MAP	0.30	1.56	8.4***	0.031	1.62	6.8***
MAI	0.026	1.64	8.9***	0.026	1.61	7.3***
PP	0.021	1.50	6.7***	0.024	1.55	6.3***

§BMDP, PLR evaluation of logistic parameters.[25] *P<0.5, **P<0.01, ***P<0.001
§§ The odds ratio for a change in the risk factor by an amount equal to its standard deviation.
Abbreviations: SBP = systolic blood pressure, DBP= diastolic blood Pressure, MAP= mean arterial pressure, MAI= mean arterial index, PP= Pulse pressure.

Table V. Multiple Logistic Coefficients and Standardised Odds Ratio of (a) Single SBP, DBP, MAP, MAI or PP and (b) Both SBP and DBP for 10-14 Years Mortality from IHD by Gender. Renfrew and Paisley, Scotland

Variables	Male			Female		
	Logistic Coefficient	Odds Ratio§	Z-Test	Logistic Coefficient	Odds Ratio	Z-Test
(a) Single component of Blood pressure						
SBP	0.017	1.45	7.22***	0.014	1.40	4.80***
DBP	0.030	1.47	7.09***	0.022	1.33	3.95***
MAP	0.029	1.52	7.84***	0.023	1.43	4.8***
MAI	0.022	1.48	7.6***	0.019	1.45	4.9***
PP	0.013	1.24	4.0***	0.014	1.29	3.5***
(b) Both Systolic and Diastolic Blood Pressure						
SBP	0.011	1.27	3.25**	0.014	1.40	4.80***
DBP	0.017	1.24	3.03**	0.008	1.11	1.05

§The approximate relative risk (odds ratio) for a change in the risk factor by an amount equal to its standard deviation. *P<0.05, **P<0.01, ***P<0.001

Abbreviations: SBP=systolic blood pressure, DBP=diastolic blood pressure, MAP=mean arterial pressure, MAI=mean arterial indedx, PP=pulse pressure.

However, SBP in males, (SOR 1.27; P<0.001) shows nearly the same predictive strength for IHD death as DBP, (SOR 1.24; P<0.001). For females, SBP (SOR 1.43; P<0.001) is a better predictor of IHD death than is the DBP (SOR 1.11; P=0.3).

DISCUSSION

Although both SBP and DBP are recognized predictors of IHD risk,[11] the purpose of the present analysis was to examine and compare the predictive strength of each component of blood pressure in males and females separately. However, this study, as well as most other studies,[1-11,28] suggests that the IHD mortality risk is significantly and independently related to the antecedent blood pressure measurements and that this risk is proportional to the blood pressure level. The risk of increased IHD mortality appeared to be related even to a single blood pressure determination, despite the effects of lability, diurnal variation, artifacts of measurements such as those caused by arm circumference, technical errors in measurement, unconscious digital selection[29] and the response to therapy.[1,30]

At any age and at any blood pressure, IHD mortality in men exceeds that in women but this does not imply that women tolerate hypertension better than men. For example, coefficients for the regression of IHD mortality on blood pressure, show values almost as large for women as men in both univariate and multivariate analysis (tables, IV, V). On the whole, SBP appeared to be the slightly better predictor of IHD than DBP in females. This was supported by MLR analysis and SND values in this study and by data from the Whitehall Study,[24] the Western Collaborative Group Study,[10] Framingham,[1] and others.[5-10] In males when analysed seprately the SBP, DBP, MAI and MAP showed essentially the same predictive strength, while the PP showed somewhat less relationship to IHD mortality. In females, when analysed separately, SBP, MAI and MAP were found to be stronger predictors of IHD mortality than either DBP or PP. When considered alone, MAP and MAI as measures of blood pressure, are slightly better indicators of risk than SBP, but SBP, MAI and MAP were better predictors of risk than DBP alone. The fact that MAP and DBP and SBP, as single measures, predict IHD mortality to the same extent is attributable to the fact that MAP are combinations of both SBP and DBP and reflect the effect of DBP and SBP, respectively. When either SBP or DBP is adjusted for the other measures, the SOR for SBP in males and females is 1.27 and 1.40 , and for DBP is 1.24 and 1.11 (not significant), with interaction between SBP and DBP in males. In males, when analysed both separately and together, SBP and DBP predict IHD mortality to the same extent, while in females SBP was found to be a stronger predictor of IHD death than the DBP, although the differences in predictive strengths were not large.

There are some factors which may contribute to the observation that SBP is slightly superior to DBP as a predictor of death from IHD as reported by many studies.[10,13,24] One explanation is that the greater variability of SBP, causing a larger standard error of its measurement, does not allow the statistical separation of the IHD and non-IHD group. With aging, a proportionally greater increase in SBP than DBP occurs. The greater difference in mean SBP between

the groups compensates for the larger variance in the measurement of SBP. As SBP level depends partly on arterial compliance,[31] they may provide a better reflection of the degree of underlying arterial disease. The failure of DBP to be a strong predictor of IHD may in part be due to greater inaccuracy in measuring DBP and to the narrower range of values available compared to SBP.

An interaction term was introduced between each component of blood pressure and BMI in addition to age, serum cholesterol level, blood glucose level, cigarette smoking habits in MLR model. In separate analyses for men and women the interaction term between BMI and blood pressure component was not significant in either males or females. This does not support the previous findings[14,32] of an interaction between blood pressure and BMI.

The present data do not suggest a declining importance of DBP, but suggest an increase in the importance of SBP in females for IHD while in males SBP and DBP predict IHD mortality to a similar extent. In both men and women MAI may be a slightly better predictor than either SBP or DBP alone.

REFERENCES

1- Kannel WB: Role of bood pressure in cardiovascular morbidity and mortality. Prog Cardiovas Dis 17:5-24, 1974.

2- Epstein FH, Ostrander SD, Johnson BC, Payne MW, Hayner NS, Keller JB, Francis T: Epidemiologic studies of cardiovascular disease in total community– Tecumseh, Michigan. Ann Intern Med 62:1170-1187, 1965.

3- Paull O, Lepper MH, Phelon WH, et al: A longitudinal study of coronary heart disease. Circulation 23:20-31, 1963.

4- Kleenbaum DG, Kupper LL, Cassel JC, Tyroler HA: Multivariate analysis of risk of coronary heart disease in Evan County, Georgia. Arch Intern Med 128:943-948, 1971.

5- Keys A, Taylor HL, Blackburn H, Brozek J, Anderson JT, Simonson E: Mortality and coronary heart disease among men studied for 23 years. Arch Intern Med 128:201-214, 1971.

6- Kannel WB, Gordon T, Schwartz MJ: Systolic versus diastolic blood pressure and the risk of coronary heart disease. The Framingham Study. Am J Cardiol 27:335-346, 1971.

7- Keys A, Arevonis C, Blackburn H, et al.: Probability of middle aged men developing coronary heart disease in 5 years. Circulation 45:815-828, 1972.

8- Wilhelmsen L, Wedel H, Tibblin G: Multivariate analysis of risk factors for coronary heart disease. Circulation 38: 950-958, 1973.

9- Levrach G, Schodel M, Seltzer M, Hart A: Assessing incidence and risk factors in myocardial infarction. Geriatrics 30:79-93, 1975.

10- Roseman RH, Shotz MS, Brand RJ: A study of comparative blood pressure meaures in predicting risk of coronary heart disease. Circulation 54:51-58, 1976.

11- Oberman A, Harlan WR, Smith M, Graybiel A: The cardiovascular risk associated with different levels and types of elevated blood pressure. Minn Med 52;1283, 1969.

12- Frochlich ED, Tarazi RC, Dustan HP: Reexamination of the hemodynamics of hypertension. Am J Med Sci 257:9-23, 1969.

13- Rabkin SW, Mathewson AL, Tate RB: Predicting risk of ischemic heart disease and cerebrovascular disease from systolic and diastolic blood pressure. Ann Intern Med 88:342-345, 1978.

14- Agetverdal A: Systolic and diastolic blood pressure as predictors of coronary heart diease in middle aged Norwegian men. Br Med J 294: 671-673, 1978.

15- Cotton CG, Nixon JM, Carpenter RG, Evans DW: Factors discriminating men with coronary heart disease from healthy controls. Br Heart J 34:458, 1972.

16- Hawthorne VM, Greaves DA, Beevers DG: Blood pressure in a Scottish town. Br Med J 3:900-603, 1974.

17- Kaddish AH, Little RA, Sternberg JC: A new and rapid method for the determination of glucose by measurement of rate of oxygen consumption. Clin Chem 14:116-131, 1968.

18- Annon W, Isherwood DM: An automated method for the direct determination of total serum cholesterol. J Med Lab Tech 26:202-211, 1969.

19- Rose GA, Holland WW, Crowley EA: A sphygmomanometer for epidemiologists. Lancet 1:296, 1964.

20- Rose GA: Standardization of observers in blood pressure measurement. Lancet 1:673, 1965.

21- Medical Research Council Committee on Chronic Bronchitis. Questionnaire on respiratory symptoms and instruction in its use. Medical Research Council, London, 1966.

22- Manual of the International Statistical Classification of Disease, Injuries and Cause of Death. Ninth Revision, Geneva: World Health Organization, 1977.

23- Annual Report of the Registrar General for Scotland. Her Majesty's Stationery Office, Edinburgh, 1979.

24- Lichtenstein MJ, Shipley MJ, Rose G: Systolic and diastolic blood pressures as predictors of coronary heart disease mortality in the Whitehall study. Br Med J 291:243-245, 1985.

25- Dixon WJ: BMDP Statistical Software. University of California Press, 1983.

26- Walker SH and Duncan DB: Estimation of the probability on events as a function of several independent variables. Biometrika 54:167-179, 1967.

27- Kahn HA: An introduction to epidemiologic method. New York, Oxford, Oxford University Press, P 111-120, 1983.

28- Brand RJ, Rosenman RH, Soltz RT, Friedman M: Multivariate prediction of coronary heart disease in the Western Collaborative Group Study compared to the findings of Framingham Study. Circulation 53:348-355, 1976.

29- Page LB, Sidd JJ: Medical management of primary hypertension (part 1). N Engl J Med 287:960-967, 1972.

30- Veterans Administration Cooperative Study Group on Antihypertensive Agents. Effect of treatment on morbidity in hypertension: results in patients with diastolic blood pressure averaging 115 through 120 mmHg 202:1028, 1967.

31- Randall OS: Effect of arterial compliance on systolic blood pressure and cardiac function. Clin Exp Hypertens [A] 4:1045-57, 1982.

32- Cambient F, Chretien JM, Ducimetiere P, Guize L, Richard JL: Is the relationship between blood pressure and cardiovascular risk depends on body mass index? Am J Epidemiol 122:434-42, 1985.