Relationship of Blood Pressure to Multiple Personal Characteristics of Workers in a Factory

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The associations of seven variables -age, body mass index, alcohol consumption, cigarette smoking, type of work and stress as related to work- with systolic and diastolic blood pressure were studied in 1447 male workers aged from 20 to 63 years in a factory. The quantification theory model I was employed to determine which variables were independently associated with blood pressure and how much were the magnitudes of associations of them.

Body mass index, alcohol consumption, age, physical exercise, cigarette smoking and stress as related to work were attained as the predictors for systolic blood pressure in decreasing order of the relation of each variable to systolic blood pressure. For diastolic blood pressure, body mass index, age, alcohol consumption, physical exercise and cigarette smoking were attained as predictors. These results were discussed comparing with the effects of each variable on blood pressure in experimental and any other population studies.

Key words : Blood Pressure, Predictor for Blood Pressure, Male Worker

INTRODUCTION

More than 40 percentage of the Japanese males who are 20 years of age or older have some degree of hypertension (blood pressure 140/90mmHg), and nearly half of these subjects have blood pressure 160/95mmHg at the time of 1980 National Nutrition Survey (The Ministry of Health Welfare 1983). Hypertension is an established cardiovascular risk factor. Numerous epidemiologic studies have reported a strong relationship between elevated blood pressure and coronary heart disease and cerebral vascular disease (Veterans Administration Cooperative Study Group on Antihypertensive Agents 1972).

Several epidemiologic studies have shown that blood pressure in adult population is consistently related to certain individual characteristics such as age, race and obesity (Hypertension Detection and Follow-up Program Cooperative Group 1977, Stamler *et al.* 1978). Recently, there has been

presented the relationship between blood pressure and certain behavioral characteristics, such as alcohol consumption, cigarette smoking and regular exercise. However, studies on the relationship between blood pressure and those characteristics in Japanese are limited in number, and the relationship of blood pressure to stress has attracted less attention. Hence, the present investigation was undertaken in factory workers to evaluate the effect of those including stress as related to work on blood pressure. We employed the quantification theory model I analysis to explore the magnitude of the independent relationship of each of seven variables to blood pressure in male workers in a factory. The seven variables were age, body mass index, alcohol consumption, cigarette smoking, regular exercise, stress as related to work and type of work.

METHODS

The subjects were 1447 males from 20 to 63 years

of age, who were workers in a machine production company. Nine hundred and seventy were office workers, and remaining 477 were factory workers. The numbers of subjects in each of the age-group 20-24, 25-29, 30-34, 35-39, 40-44, 45-49, 50-54 years, and 55 years and older were 70, 132, 260, 263, 286, 209, 140 and 87, respectively. The subjects who used antihypertensive drugs were not included in this study.

Systolic (SBP) and diastolic blood pressure (DBP), height and body weight were measured. Blood pressure was measured in the left arm with the subject seated. The systolic and fifth phase diastolic blood pressure were recorded. Antihypertensive medication were also recorded. Before the blood pressure measurement, a questionnaire including questions on alcohol use, cigarette smoking, exercise, and stress as related to work, was taken. Age at last birthday was determined and divided into four groups i.e. (1)20-29, (2)30-39, (3)40-49, and (4)50 years and older. Obesity ratio $[\text{weight(kg)} / ((\text{height(cm)} - 100) \times 0.9) \times 100]$ (%) was employed as a body mass index, and grouped into 4 categories: (1)-89%, (2)90-110%, (3)111-120%, and (4)-121%. As regard to smoking, the following classification was made according to the extent of smoking: (1) None, (2)1-10, (3)11-20, (4)21-30, and (5)31 cigarettes/day and over. The duration of smoking and earlier smoking habit were not appeared from the collected data. The alcohol consumption was estimated from answers to standardized questions. The alcohol consumption was converted into milliliters of the ethanol per day using a formula which considered the different amounts of ethanol in beer, wine, sake and whisky. The alcohol consumption was introduced into analysis in ordinal scale with codes (1): None, (2): slightly ($\leq 30\text{ml/day}$), (3): moderate ($31-60\text{ml/day}$), (4): high ($61-90\text{ml/day}$), (5): abuse (91ml/day). Physical exercise in leisure time was evaluated by a standardized question, and converted into ordinal scale with codes (1): None, (2): occasionally (1-2times/month), (3): regularly (1

-2times/week), (4): regularly often (3times/week-). The stress as related to work was determined by an answer to the question; "Do you have mental stress as related to work?"; (1): no, (2): moderate, (3): high. The type of work of each subject was classified into two categories, i.e. (1): office work, and (2): field work.

In this study, the quantification theory model I was used for the assessment of blood pressure. The quantification theory which is a method of analysis using qualitative data. Model I applies to the prediction of the numerical external criterion from the qualitative data. In this study, stepwise methods were applied for the selection of variables as a reasonable procedure to decrease the number of them.

RESULTS

Systolic and diastolic blood pressures by 5-year age groups were presented in Figure 1. Both systolic and diastolic blood pressures were progressively higher with increasing age. Means and standard deviations of systolic and diastolic blood pressures for all subjects were 124.1 ± 15.8 and 76.3 ± 10.6 mmHg respectively.

The normalized scores and partial correlation

Figure 1. Means and standard deviations of systolic and diastolic blood pressure by age.

coefficients from the quantification theory model I analysis were shown in Table 1. By the applications of stepwise method, the following six variables were attained as the predictors for systolic blood pressure: body mass index, alcohol consumption, age, physical exercise in leisure time, cigarette smoking, and stress as related to work, in decreasing order of the magnitude of the partial correlation coefficients. Type of work was not significantly associated with systolic blood pressure. For diastolic blood pressure, body mass index, age, alcohol consumption, physical exercise in leisure

time and cigarette smoking were attained as the predictors. Type of work and stress as related to work were not significantly associated with diastolic blood pressure.

The multiple regression coefficients between actual blood pressure and estimated blood pressure were 0.310 and 0.363 for systolic and diastolic blood pressure, respectively, which were highly significant ($P < 0.001$).

DISCUSSION

The present study was made on the workers in a

Table 1. Number of cases, normalized scores and partial correlation coefficients derived from quantification theory model I.

Variable	Category	Number of cases	Normalized score	SBP Partial corr. coeff.	Normalized score	DBP Partial corr. coeff.
Age (years)	1: 20-29	202	-0.90	0.117	-3.36	0.171
	2: 30-39	523	-0.37		-0.37	
	3: 40-49	495	-1.11		0.38	
	4: 50-	227	4.07		3.02	
Type of Work	1: Office work	970	-	-	-	-
	2: Field work	477	-		-	
Obesity ratio (%)	1: - 89	126	-5.98	0.208	-3.33	0.239
	2: 90-100	827	-1.09		1.16	
	3: 111-120	316	1.20		1.15	
	4: 121-	178	7.15		5.68	
Alcohol consumption (ml/day)	1: None	259	-2.55	0.143	-2.14	0.143
	2: -30	415	-1.32		-0.89	
	3: 31-60	370	0.04		0.42	
	4: 61-90	263	1.88		1.33	
Smoking (cigarettes/day)	5: 91-	140	4.97		1.81	
	1: 0	635	0.00	0.086	0.49	0.074
	2: 1-10	107	-4.03		-1.12	
	3: 11-20	395	-0.09		-0.92	
	4: 21-30	229	1.61		0.28	
Physical exercise	5: 31-	81	1.27		1.35	
	1: None	586	0.64	-0.088	0.82	-0.094
	2: Occasionally	227	-0.07		0.02	
	3: Regularly	273	1.55		0.34	
Stress as related to work	4: Regularly often	361	-2.16		-1.59	
	1: None	737	-0.63	0.039	-	-
	2: Moderate	499	0.45		-	
	3: High	211	1.11		-	
Constant			124.40		76.36	
Multiple corr. coeff.			0.310		0.363	
Standard error			15.16		9.93	
F-value			8.00		12.74	

factory. The blood pressures in Figure 1 for our study were 5-10mmHg lower than those at the time of 1980 National Nutrition Survey (The Ministry of Health Welfare 1983). This seems to be partly influenced by an exception of the subjects under antihypertensive medication in the present study. Our study was cross-sectional, and therefore, cause and effect relationship between the independent variables studied and blood pressure cannot be inferred. However, evidences supporting possible casual associations are reviewed, and the potential public health implications are discussed.

The finding of increasing blood pressure with age has been universally reported in industrialized societies (WHO 1978). In the present study, age was significantly associated with blood pressure. Normalized score of age for systolic blood pressure for 50 years and older age-group was significantly higher than those for other age-groups. Normalized scores of age for systolic blood pressure under 50 years groups were not significantly different from each other. On the other hand, normalized scores of age for prediction of diastolic blood pressure were significantly different among age-groups. It is assumed that the effects of age on systolic blood pressure were different from on diastolic blood pressure.

The strong association of body mass index with both systolic and diastolic blood pressure has been repeatedly presented (Stamber *et al.* 1978, Criqui *et al.* 1982, 1983), and was observed in this study. The magnitude of this association was the greatest among seven variables (Table 1). It has been shown that the weight and blood pressure reductions were directly associated in overweight hypertensive patients in the clinical studies. Since a sizable population of hypertensive patients were obese, weight reduction should be recommended as the initial step in the treatment of any hypertensive patients who were above ideal weight (Reisin *et al.* 1983).

The consistent association of alcohol con-

sumption with blood pressure has repeatedly reported in population studies (Beevers 1977, Criqui *et al.* 1983), and again shown by our data. In the experimental study, Grollman (1930) found that small amounts of alcohol increased blood pressure in healthy volunteers. On the other hand, no such acute changes were presented in healthy volunteers (Miyazaki 1974, Kupari 1983) and in patients with ischaemic heart disease (Orland *et al.* 1976). Potter and Beevers (1984) presented that the blood pressure in patients with essential hypertension, who had a daily alcohol intake, increased by alcohol consumption and decreased by alcohol abstention.

In the experimental studies, cigarette smoking caused a definite increase in blood pressure (Asano *et al.* 1977). On the other hand, the negative and no association of blood pressure with cigarette smoking were found in the population studies (Criqui *et al.* 1982, 1983). In this study, cigarette smoking significantly associated with blood pressure, the magnitude of association of blood pressure with cigarette smoking, however, was very small, and was not associated in order of number of cigarettes smoked per day. For example, the normalized score of cigarette smoking for the subject who smoked 1-10 cigarettes per day was significantly lower than that for non-smokers. In this study, the subjects who gave up smoking were included in non-smokers group. As the blood pressure increase had been reported in subjects quitting smoking (Seltzer 1974), the higher normalized score for non-smokers than those for moderate smoked subjects could be explained partly by the increase blood pressure by quitting smoking.

There was a negative association of regular exercise with blood pressure. Among the normalized scores of regular exercise, the score for the subject who performed exercise 3 times per week and over was significantly lower than those for other categories, which indicated that regular exercise over 3 times per week was useful in decreasing blood pressure. It has been demonstrated

repeatedly that exercise training produced significant decrease in blood pressure (Boyer and Kasch 1970, Choquette and Ferguson 1973, Yoshida *et al.* 1983). Crigui *et al.* (1982) reported that the relationship between exercise and blood pressure was not statistically significant with analysis of a limited single-question assessment of exercise, i.e. determined by a yes or no answer to the question "Do you regularly engage in strenuous exercise or hard physical labor?". It means that the degree and frequency of exercise was important to decrease blood pressure.

The stress as related to work was associated with systolic blood pressure but not diastolic blood pressure. It has been demonstrated that a man exposed to stress may react with increased blood pressure in the experimental study (ILO 1983). There were, however, very few population studies on association of stress with blood pressure. Therefore, it is not known whether the increasing blood pressure was caused by the chronic and/or repeated exposure to stress and whether the effect of stress on systolic blood pressure was different from on diastolic blood pressure. The reasons for the elevated systolic blood pressure in the subjects having stresses as related to work in the present study cannot be clarified. However, the stress have to be taken into consideration in the investigation on the relationship between blood pressure and personal characteristics of the subjects because of the significant association of the stress as related to work with systolic blood pressure in the present study. More researches on the chronic effects of stress on blood pressure will be required in future.

The type of work was not associated with blood pressure in this study. A recent report indicated that men who had higher daily energy expenditure were less likely to develop hypertension than sedentary men (Paffenbarger *et al.* 1979). There is no heavy muscular work in this factory for mechanization and automation in field work. The small difference in energy expenditure between office and field work

could assume the insignificant association of type of work on blood pressure.

Body mass index, alcohol consumption, age, physical exercise, cigarette smoking and stress as related to work were attained as the predictors for systolic blood pressure in decreasing order of the magnitude of the relation of each variable to systolic blood pressure. For diastolic blood pressure, body mass index, age, alcohol consumption, physical exercise and cigarette smoking were attained as predictors. These variables with the exception of age may be amenable to public health intervention, with or without concurrent hypertensive therapy (Crigui *et al.* 1982). The reducing of elevated blood pressure was found by alteration of these behavioral variables (Hypertension Detection and Follow-up Program Cooperative Group 1979, Report by Management Committee 1980).

The coefficient of multiple determination, R^2 , is a measure of the predictive value of predictors used in a multivariate analysis, i.e. it presents how well the predictors can explain the total variance of the dependent variable. The R^2 values were 0.096 and 0.132 for systolic and diastolic blood pressure, respectively. The unexplained variance, $1-R^2$ which was about 0.9 for both systolic and diastolic blood pressure, is partly due to the magnitude of the influence from unmeasured disturbing variables, such as nutritive status (Shigiya *et al.* 1975) and genetic factor (Sasaki 1975) on blood pressure.

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