Perceived Job-stress and Blood Pressure Increase Among Japanese Blue Collar Workers: One-year Follow-up Study

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Abstract: To investigate the relationship between job-stress and blood pressure increase, 373 male blue collar workers without hypertension were followed for one year. 5 kinds of perceived job-stress were assessed by means of mailed questionnaires. Stepwise multiple regression analysis was conducted to examine significant determinants of blood pressure increases during follow-up. Job-stress due to complicated machine operation was found to be a significant predictor of diastolic blood pressure increase independent of other significant factors, i.e., systolic and diastolic blood pressure at the beginning of the follow-up, age, total serum cholesterol, alcohol consumption, type A behavior and family history of hypertension. Job-overload, physical discomfort, human relations and job-dissatisfaction, on the other hand, bore no significant relation to systolic and diastolic blood pressure increases. The results suggest that the use of production machines involving complicated operations and newly developed technology might be a risk factor for high diastolic blood pressure.

Key words: Job-stress—Blood pressure—Risk factors—Follow-up study—Blue collar workers—Questionnaire survey

INTRODUCTION

High blood pressure is a major factor related to atherosclerosis and its complications, mainly coronary heart disease and cerebrovascular diseases. Cobb and
Rose\textsuperscript{1)} reported that hypertension was prevalent in air traffic controllers with high job-stress levels. However, differing and conflicting evidence exists in studies on the relationship between job-stress and hypertension.

Series of studies have shown that various kinds of psychosocial job-stress are significantly related to high blood pressure in industry: recent life-events including job-change,\textsuperscript{2)} both quantitative and qualitative workload,\textsuperscript{3–5)} role conflict and low rewards,\textsuperscript{3)} job-ambiguity,\textsuperscript{4)} and job-dissatisfaction.\textsuperscript{5,6)} Work-related anxiety as a stress symptom was found to be correlated with higher blood pressure.\textsuperscript{7)} Yet other studies\textsuperscript{8–10)} have reported no relationship between job-stress and blood pressure. Chesney \textit{et al.}\textsuperscript{11)} also found no significant relationship until type A behavior was adjusted for.

Most studies are cross-sectional\textsuperscript{1,3–11)} or semi-prospective with no data at the beginning of follow-up.\textsuperscript{2)} In a 5-year cohort of male blue collar workers, Aro\textsuperscript{12)} reported that an employee's tendency to suppress his own emotions at work was only significant with respect to increasing diastolic blood pressure. A few studies\textsuperscript{3,5–7,12)} have considered other health-related variables such as alcohol drinking, obesity and smoking; none included other risk factors for hypertension such as family history of hypertension or blood chemical data. Moreover, highly automated systems of production have been recently introduced to the workplace in Japan as well as in other industrialized countries; workers may suffer stress as a result of using production machines demanding high technical skills of their operators while permitting little autonomy. The chronic effects of this stress on blood pressure have not been adequately investigated.

The purpose of the present study is to clarify the relationship between perceived job-stress and blood pressure increase in a one-year follow-up study of Japanese blue collar workers. In particular, this study examines the effect of stress due to the use of newly introduced production machines while controlling for other well-known risk factors, e.g., alcohol drinking, smoking, obesity, family history of hypertension, physical exercise, salt intake and blood chemical data.

\textbf{Subjects and Methods}

\textit{Subjects}

In the fall of 1984, a total of 1,266 full-time employees of an electrical factory were surveyed using a self-administered questionnaire. 1152 or 91\% of the workers responded. They were also interviewed, and blood pressure measurement and blood chemical analysis were performed. The following analysis was made for 420 male blue collar workers between the ages 20 to 49 years. They were employed in repetitive tasks in 4 major kinds of electric cable and semi-conductor circuit production lines. 24 workers of this group had received medical treatment for hypertension. Another 18 had high blood pressure diagnosed as hypertension according to WHO criteria, i.e., either more than 160 mmHg systolic or 95 mmHg diastolic pressure. They were omitted from the following analysis.
378 workers selected on the basis of the primary questionnaire survey were followed and 374 were re-examined one year later. One worker who had received medical treatment for hypertension during follow-up was excluded. Mean age ± standard deviation (SD) of the 373 workers was 36.8 ± 8.5 years.

Methods

The questionnaire concerning background data, job-stress and health-related behavior was mailed to the subjects in September, 1984. Health examinations were made within one month from the mailing and again one year later. The examination included an interview concerning past history of major disease, measurement of blood pressure and blood chemical data, and physical examination.

Predictor variables. Seventeen items of psychosocial job-stress and work environment were assessed by means of the questionnaire at the beginning of follow-up; 10 were 4-point Likert type scales; 7 were two-point. The scores for each item were transformed so that higher scores indicated higher perceived stress. In order to obtain empirically derived measures for this sample, these items were subjected to principal components factor analysis with varimax rotation. Five factors with eigen values greater than 1.0 were extracted, and they accounted for 52% of the total variance. The items were classified into one of these factors according to their factor loadings. A total score of the items classified was used as a measure of corresponding job-stress. The items in each scale are listed in the Appendix. Job-overload (4 items) referred to the amount of quantitative and qualitative pressure perceived by workers. Physical environment (5 items) measured complaints concerning physical environment: hot, cold, dark, dirty, noisy. Job-dissatisfaction (3 items) assessed how much workers were personally dissatisfied with their jobs. Human relations (3 items) measured the amount of interpersonal problems with workplace members. Machine operation (2 items) referred to whether workers perceived that they were using a complicated production machine and newly introduced technology. Four of these scales had good internal consistency with alpha coefficients ranging from 0.51 to 0.69, but consistency was slightly lower in stress due to complicated machine operation, i.e., 0.38. In addition, shift work, recent job-change and hours of overtime per month were assessed by means of individual questions. Recent job-change means a change of either position, worksite or job description within 6 month before the primary questionnaire survey.

Health-related behaviors consisted of alcohol consumption, number of cigarettes currently smoked per day, salt intake and physical activity. Alcohol consumption was assessed based on type of alcohol and frequency of consumption; pure ethanol intake (ml) per week was estimated. Decrease in salt intake was assessed by means of a single question asking whether workers were taking care not to ingest too much dietary salt. Physical exercise in leisure time was also assessed by means of a single question about regular habits of sports or exercise. In addition, obesity was measured using a body mass index calculated by determining the
ratio of body weight (kg) to height in meters (m) squared at the beginning of follow-up. Body weight increase was measured as percent body weight increase at follow-up. Laboratory tests provided measurements of serum cholesterol, triglyceride and uric acid. Family history of hypertension was assessed on the basis of whether the subjects’ father or mother had ever received medical treatment for hypertension.

Type A behavior was measured using an original scale derived from the Bortner Short-Rating Scale. It consisted of 5 items as follows: hard-driving; strict punctuality; impatience; competence; desire for approval by others (see Appendix). The higher the total score is, the greater the tendency toward type A behavior is. The internal consistency of this scale was 0.64 as measured by the alpha coefficient for the sample.

Blood pressure measurements were carried out by trained nurses at the beginning and end of the follow-up period. Blood pressure was measured by the same type of calibrated automatic manometer throughout. Systolic and diastolic blood pressures were measured in the sitting position using the right arm after a short rest. All readings were made to the nearest even number (mmHg) and no digit preference was observed.

Data analysis

The subjects were divided into three groups according to job-stress score, i.e., approximately the upper 25%, the next 25% and lower 50%, to identify those portions of the sample that could be considered “high”, “moderate” or “low” with respect to a given job-stress measure. Systolic and diastolic blood pressures and increases in them over the one-year period were compared among these job-stress groups and the groups classified on the basis of recent job-change and overtime using the t-test. Multiple linear regression was employed to examine the relationship between the job-stress scores and increases in systolic and diastolic blood pressure while other predictor variables were adjusted. In the multiple linear regression analyses, dichotomous variables were scored as yes = 1 and no = 0 (e.g., married = 1 and not married = 0 in the case of marital status). These analyses were made using SPSS-X computer programs at the Computer Center of Tokyo University.

Results

Mean systolic and diastolic blood pressures at the beginning of follow-up were 124.2 (SD 12.5) mmHg and 72.7 (SD 10.6) mmHg, respectively. Mean increases in systolic and diastolic blood pressures at follow-up were 1.1 (SD 11.9) mmHg and 1.2 (SD 10.0) mmHg, respectively.

Figure 1 shows a comparison of increases in mean diastolic blood pressure values over a one year period among the groups based on their complicated machine operation scores. Mean values increased with the level of job-stress and
were significantly different between the high and low stress groups. No significant differences among these groups were observed with respect to initial systolic and diastolic blood pressures or increase in systolic blood pressure (p>0.05).

Table 1 shows mean systolic blood pressure values and increases among the groups classified on the basis of overtime. Initial systolic blood pressure was significantly higher and its increase was significantly less in the group with 51 or more overtime hours per month than in the group with 25 or less. No significant differences among these groups were observed with respect to diastolic blood pressure or increase in it (p>0.05).
Diastolic blood pressures at the beginning were significantly higher in the 65 subjects with a recent job-change than the remaining 308 subjects (p<0.05); mean values were 75.1 (SD 10.5) and 72.2 (SD 10.5), respectively. No significant differences in initial systolic blood pressure or in one-year increases in systolic or diastolic blood pressures were observed between these two groups (p>0.05). No significant differences among the groups with respect to the other 4 perceived job-stress and the production lines where the subjects were employed, were observed in initial systolic and diastolic blood pressures or in their increases (p>0.05).

Table 2 shows the significant variables in a stepwise multiple regression analysis of increases in diastolic blood pressure over a one year period with respect to 7 job-stress variables and 11 other possible risk factors. Job-stress scores for complicated machine operation were positively and significantly associated with increases in diastolic blood pressure. Initial diastolic blood pressure was strongly and negatively correlated with increase in itself. Age, serum cholesterol, alcohol consumption, type A behavior and family history of hypertension were positively associated with increases in diastolic blood pressure. In the multiple linear regression analysis of increases in systolic blood pressure, number of cigarettes, alcohol consumption and body weight increases were positively and significantly associated (p<0.05).

**DISCUSSION**

In the present study job-stress due to complicated machine operation was a significant predictor of increases in diastolic blood pressure during a one-year follow-up period. This effect was independent of other significant risk factors, namely, age, alcohol consumption, cigarette smoking, obesity, type A behavior

<table>
<thead>
<tr>
<th>Significant variable</th>
<th>Beta coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diastolic blood pressure, initial</td>
<td>-0.716**</td>
</tr>
<tr>
<td>Age</td>
<td>0.222**</td>
</tr>
<tr>
<td>Systolic blood pressure, initial</td>
<td>0.203**</td>
</tr>
<tr>
<td>Total cholesterol</td>
<td>0.118**</td>
</tr>
<tr>
<td>Alcohol consumption</td>
<td>0.104*</td>
</tr>
<tr>
<td>Type A behavior</td>
<td>0.102*</td>
</tr>
<tr>
<td>Job-stress due to complicated machine operation</td>
<td>0.099*</td>
</tr>
<tr>
<td>Family history of hypertension (yes=1, no=0)</td>
<td>0.096*</td>
</tr>
<tr>
<td>Multiple R</td>
<td>0.621</td>
</tr>
</tbody>
</table>

a Significance level for entry into the model was p<0.05.
* p<0.05, ** p<0.01.
and family history of hypertension. The results suggest that the use of unfamiliar machines involving complicated operations may be a risk factor for high blood pressure.

To explain the possible relationship between the stress due to complicated machine operation and elevation of diastolic blood pressure, the following mechanisms were considered: 1) Laboratory studies15) on the physiological effects of mental loading have reported that job difficulty causes temporary blood pressure elevation. The daily use of a complicated and unfamiliar machine which demands higher levels of operator attention may lead to sustained blood pressure elevation. 2) Frequent machine breakdowns and delays are familiar problems with advanced technology16) and were actually observed in the factory where the present study was made. These unexpected affairs which cannot be controlled or corrected by the operators themselves may be perceived as greatly disturbing. Prolonged anxiety and tension brought about as a result of such situations may increase blood pressure as previously reported.7) 3) The use of high-technology machines may lead to decreased physical activity at work which in turn may affect blood pressure.

The present study does have some limitations, however. First, the present study failed to show any significant association between stress due to complicated machine operation and initial diastolic blood pressure. When the use of new and complicated machinery started a short time before the survey began, no relationship between the job-stress and initial blood pressure could be detected. In the present study, it is not clear when workers started to use complicated machines or when new technology was introduced. Second, the present study assessed job-stress variables only once at the beginning of follow-up. The results can be interpreted another way, i.e., that the introduction of higher technology increases other job-stress, such as job-change and overtime, which more directly cause blood pressure elevation. Further studies involving repeated measurements of various kinds of job-stress and blood pressure during a longer follow-up period, are required to confirm the present results and explain the possible mechanisms. An investigation of job-stress and blood pressure before and after actual changes in production machines in the workplace may be more useful.

Overtime was positively associated with systolic blood pressure at the beginning. This is in agreement with previous cross-sectional studies3-5) which reported a relationship between blood pressure and job-overload. Overtime, however, was negatively correlated with systolic blood pressure increase (Table 1) and was not significantly correlated in the multiple linear regression analysis. The results suggest that the effect of overtime on blood pressure may be temporary when overtime hours vary from time to time. The present results suggest that a recent job-change may lead to acute blood pressure elevation sustained for more than one year. It has been reported that life-events cause blood pressure elevation.2) Job-change should be considered a risk factor for hypertension in future studies. None of the other four measures of perceived job-stress were correlated significantly
with either initial systolic and diastolic blood pressure or with increases during follow-up. This is consistent with some earlier studies. Further studies should be conducted to clarify the interaction between personality and job-stress as previously suggested.

Systolic and diastolic blood pressures were negatively correlated with increases in their own value over a one-year period. This is probably due to 1) "regression to the mean" and 2) better health-related behavior among workers with higher blood pressure during follow-up as directed by public health nurses at the factory.

Many studies have shown that alcohol consumption is correlated with blood pressure. The present results are consistent with these findings and add prospective evidence on the effects of alcohol drinking on increases in blood pressure. Body weight increase, serum cholesterol and family history of hypertension were correlated with increases in diastolic blood pressure. These results are consistent with previous investigations on the effects of nutritional and hereditary factors on blood pressure. Number of cigarettes smoked was found to be significantly associated with increases in systolic blood pressure in the present study. Most studies have reported negative associations between smoking and blood pressure when obesity was adjusted for. It is likely that changes in smoking habits during follow-up, e.g. smoking cessation and reduction in the number of cigarettes smoked, are responsible for the increase in systolic blood pressure observed.

Type A behavior, which is a well known risk factor for coronary heart disease, was also found to be significantly correlated with increased diastolic blood pressure. Earlier studies found no significant relationship between type A behavior and blood pressure. There may be a cultural difference in the effects of type A behavior on blood pressure between Japan and Western countries. This interpretation is, however, limited by the fact that the type A scale is not well validated in the present study.

In conclusion, the present results suggest that job-stress due to complicated machine operation may be a risk factor for increased diastolic blood pressure, and further investigations are needed on this issue. It is important to note that the present study was made in a sample of male blue-collar factory workers. The effects of stress due to complicated machine operation might be modified by means of technical support and job-training in the factories. Further studies are needed to replicate the results in other factories and generalize the present results to female and white-collar workers. Such future research may contribute to understanding the psychophysiological mechanisms of and developing preventive measures against the adverse effects of introducing high technology to the workplace.
APPENDIX

1. Measures of perceived job-stress

   Job overload:
   - How do you feel about the amount of your work?
   - How often do you feel exhausted at the end of a day?
   - How often do you feel pressured by work?
   - How often do you think about work at home?

   Physical environment:
   - Is it hot where you work?
   - Is it cool where you work?
   - Is it noisy where you work?
   - Is it dirty where you work?
   - Is it dark where you work?

   Job-dissatisfaction:
   - Are you able to control the pace of your job?
   - Do you feel your job is suited to you?
   - Are you satisfied with the results of your work?

   Human relations:
   - Do you have interpersonal problems at work?
   - Do you feel that you are thought of as a less important person?
   - Do you feel that your coworkers talk about you?

   Complicated machine operation:
   - Do you operate a complicated production machine?
   - Has a new machine or new technology been introduced where you work?

   A 4-choice response scale was used for job-overload, job-dissatisfaction and human relations ("very much", "moderate", "a little", "none"); a 2-choice response scale was used for physical discomfort and complicated machine operation ("yes", "no").

2. Assessment of type A behavior

   - Do you easily become driven about something?
   - Are you fastidious about being on time?
   - Do you want to excel in your work?
   - Are you competitive?
   - Do you get upset when you have to wait for a person or a train?

   A 4-choice response scale was used ("often", "sometimes", "a little", "none").

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REFERENCES


