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ASSOCIATION OF CHANGE IN THE TYPE OF JOB WITH PREVALENCE OF COMPONENTS OF THE METABOLIC SYNDROME—SPECIAL REFERENCE TO JOB STRESS

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Objective It is well established that job stress is a leading cause of cardiovascular disease. The relationship with the metabolic syndrome, however, has received only limited attention. The present study was designed to investigate associations between change of the type of job and the prevalence of metabolic syndrome components from the aspect of on-the-job stress and alteration in life style.

Methods Thirty-six male workers of the manufacturing department were transferred to the car-sales department at the same automobile company in 1992 to 1993. These same workers were transferred back to the manufacturing department after two years. We compared the first health-check data before the transfer in 1992 (Term A), a second set of data two years after transfer in 1994～95 (Term B) and a third set of data two years following transfer back to the manufacturing department in 1996～1998 (Term C). The workers were requested to provide information about drinking and smoking habits, and answer Karasek's questionnaire and a simple stress questionnaire in order to clarify the possibility of job stress in occurrence of the metabolic syndrome, defined in terms of obesity, hypertension, dyslipidemia, and impaired glucose tolerance as components.

Results Five workers had two or more components of the metabolic syndrome before the transfer to the car-sales department (Group I). One demonstrated improvement, three no change, and one increase in symptoms from A to B. Seven workers had more than two components after the transfer to car-sales department (Group II), and six of them exhibited decrease two years following transfer back to the manufacturing department. Five of them also showed elevated liver enzymes in serum with the appearance of the components, and three of them demonstrated recover. Three workers had two components of the metabolic syndrome only at time point C (Group III), while the remaining 21 workers had 0 to one component throughout the observation period (Group IV). Amount of drinking and smoking increased significantly when working in the sales department but these items returned to the previous values after rejoining manufacturing, though differences were not observed between workers with (Group II) and without (Group IV) components of the metabolic syndrome. Body mass index (BMI) and alanine aminotransferase (ALT) increased significantly when workers moved to the sales department and that was significant in Group II as compared to Group IV. Three components of Karasek's JCQ changed significantly during job transfer, though differences were not observed between the workers with (Group II) and without (Group IV) components of the metabolic syndrome. Logistic regression analysis with age, lifestyle, Karasek's JCQ, and ALT revealed that elevation of ALT value was associated with having two or more components of metabolic syndrome, while hours of sleep demonstrated an inverse association.

Conclusion Elevated ALT and reduction of sleep hours may be associated with development of the metabolic syndrome in workers who change their type of job.

Key words: metabolic syndrome, stress, Karasek's JCQ, changing types of job, alanine aminotransferase

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I. Introduction

It is well known that job stress is one of the leading causes of cardiovascular disease[1)] and that groups suffering high strain at work are at a greater risk in several studies[2,3]. The relationship between job stress and metabolic syndrome, however, has received only limited attention. We earlier reported that change in the type of job may cause hypertension, dyslipidemia, glucose intolerance, obesity and elevated alanine aminotransferase (ALT) in male workers[4,5] who worked in manufacturing and were transferred to the sales department because the automobile company was having financial difficulties.

Karasek reported that job-related stressors fall into three categories, "Job Demand," "Decision Latitude" and "Social Support"[6]. "Decision Latitude" is composed of "skill discretion" and "decision authority" and "Social Support" is composed of "supervisor support" and "coworker support". Increase in Job demand, decrease in Decision Latitude and/or decrease in Social Support have been reported with on-the-job stress[6]. We used Karasek's JCQ questionnaire to analyze job-related stressors in our previous study and it was again employed here.

Moreover, recent evidence indicates that nonalcoholic fatty liver disease (NAFLD), usually observed at workplace health checkups, is related to the metabolic syndrome and may indeed be one of its early manifestations[7]. Our previous study showed that workers may develop liver dysfunction with uncertain etiology after moving from car manufacturing to sales departments[4,5]. Therefore, it is reasonable to suppose that changing the type of job may be a cause of the metabolic syndrome.

The present study was designed to investigate the participation of on-the-job stress and/or changing life style associated with job transfer in the development of metabolic syndrome in automobile company employees. We also investigated the relationship with elevated liver enzymes.

II. Methods

Study Subjects

The subjects of the study were sixty-one male workers who had worked in manufacturing but were transferred to the sales department between December 1992 and December 1993 under orders from their supervisors. Thirty six workers who were followed until 1998 and received annual health checkup required by law described below as well as filled in the Karasek's Questionnaire[6,8] fulfilled the inclusion criteria. The average age was 32.5 ± 7.7 years old, and the duration of working in sales was 25.4 ± 0.5 months. Occupational health physicians (Mikurube and Kaneko) followed them from 1992 to 1998.

Workers are required every year by law in Japan to have a routine health examination, including questionnaires on their health condition, physical examination and blood chemistry. All 36 subjects of this study had three sets of health check data before transfer to car-sales (1992), 2 years after their transfer to car-sales (1994～1996) and 2 years after the transfer back to manufacturing (1996～1998). These three job terms are designated Term A, Term B and Term C, respectively.

The occupational health physicians explained the purpose of the study to each worker and each subject was asked to provide information on past medical history of illness and to fill out questionnaires regarding drinking and smoking habits, diet, health condition, physical activity, sleep time and current drug use. The subjects underwent a physical examination, conventional laboratory tests including urinalysis, peripheral blood examination (red and white blood cell counts, hemoglobin), clinical blood chemistry [blood sugar level, total cholesterol, triglyceride, HDL-cholesterol, creatinine, aspartate aminotransferase (AST), alanine aminotransferase (ALT), γ-glutamyl transpeptidase (γ-GTP)], electrocardiogram, and chest X-rays at each annual health check. All subjects signed informed consent forms to participate in this study. The ethics committee of the Tokai University School of Medicine as well as the health care committee of the automobile company approved the study protocol.

Alcohol Drinking and Smoking Habits

The subjects filled out questionnaires about alcohol drinking and smoking. To avoid underreporting the amount of alcohol or smoking and obtain accurate data, we carefully explained to the subjects that the questionnaires would be used only for research purposes.

Regarding drinking habits, the questionnaire asked about the number of drinking days per week and daily alcohol intake. The amount of alcohol intake was calculated using the following standards: one 350-ml can of beer, one 120-ml glass of table wine, and one 90-ml cup of Japanese sake each contains 10 g of ethanol. Data were calculated as ethanol consumption (g) per week.

Questions on smoking included the number of cigarettes per day and smoking history.

Evaluation of Liver Dysfunction

The serum levels of three liver enzymes, i.e., AST, ALT, γ-GTP, were used to determine liver dysfunction. A subject was considered to have liver dysfunction with AST $\geq$ 40 IU/l, ALT $\geq$ 40 IU/l, and/or γ-GTP $\geq$ 60 IU/l.

Evaluation of the Components of Metabolic Syndrome

We evaluated the subjects for obesity, hypertension, dyslipidemia and impaired glucose tolerance as components of metabolic syndrome (the upper and lower limits for the risk factors are shown below in parentheses). We categorized the subjects as follows: for BMI, lean (BMI < 19.8; 10% lower than the average of normal BMI, 22), normal (19.8 ≤ BMI < 24.2), and obese (24.2 ≤ BMI; 10% higher than the average normal BMI, 22). Hypertension (systolic blood pressure ≥ 140 mmHg and/or diastolic blood pressure ≥ 90 mmHg), dyslipidemia (total cholesterol ≥ 220 mg/dl and/or triglyceride ≥ 150 mg/dl and/or HDL-cholesterol ≤ 40 mg/dl), and impaired glucose tolerance (fasting plasma glucose ≥ 110 mg/dl or spontaneous plasma glucose level ≥ 140 mg/dl) were also assessed.

Stress Evaluation by Karasek's Questionnaire

The Job Content Questionnaire (JCQ) was originally developed by Karasek[6]. All subjects in the present study filled out Karasek's Questionnaire in the Japanese version written by Kawakami[8]. The questionnaire composes 22 questions, 5 of them on psychological job demands, 9 on decision latitude, and 8 on social support. Six of the 9 questions on decision latitude involve skill discretion and 3 decision authority. Four each of the 8 questions on social support involve supervisor and coworker support. Responses to the questions were selected from the following: 1. very different, 2. different, 3. right, 4. just right. The above three big categories (job demand, decision latitude, and social support) were scored using the scale of the JCQ user's guide[6,8].

In order to determine if the workers felt stress during working in car-sales, a simple alternative questionnaire was prepared by the present authors. Both stress evaluations were analyzed to confirm JCQ. After the JCQ data were checked, they were used for the analysis in relation to the prevalence of the metabolic syndrome and elevated liver enzymes.

Statistical Analyses

Categorical variables were assessed by the chi-square or Fisher's exact tests. Quantitative values are expressed as means ± standard deviations (SDs). The paired t test was used to analyze differences between scores for Karasek's Questionnaire in workers before and after job transfer. Differences in the laboratory data in workers during job transfer were analyzed by repeated-measures analysis of variance (ANOVA). Logistic regression analysis was performed to predict factors associated with having two or more components of the metabolic syndrome when the workers moved to sales department (dependent variable). As independent variables, age, smoking (number of cigarettes/day) and drinking (ethanol consumption/week) habits, score of Karasek's Questionnaire, hours of sleep and work and value of ALT were used. A level of $p < 0.05$ was considered significant. All analyses were performed with the computer program SPSS.

III. Results

Changing Type of Job and Accumulation of Metabolic Syndrome Components

Changes of average physical and clinical chemistry data during the period studied (Term A, B and C) were analyzed by repeated-measures ANOVA in the 36 male workers (Table 1). BMI increased significantly in Term B (sales period) and recovered in Term C. Neither systolic nor diastolic blood pressure showed significant differences. Total cholesterol and triglyceride showed a tendency to be higher in Term B but did not recover during Term

Table 1. Physical and laboratory data for the 36 subjects

N = 36	A: manufacturing	B: sales	C: manufacturing
BMI (kg/m^2)	21.73 ± 2.44	23.9 ± 2.91*	22.9 ± 2.46
SBP (mmHg)	126.4 ± 10.4	122.8 ± 11.1	124.5 ± 12.1
DBP (mmHg)	76.97 ± 6.69	78.72 ± 8.67	76.11 ± 8.01
Total cholesterol (mg/dl)	169.5 ± 35.3	182.5 ± 38.3	185.2 ± 34.3
HDL-cholesterol (mg/dl)	—	54 ± 9.3	57 ± 13.9
Triglyceride (mg/dl)	89.4 ± 61.6	117.9 ± 69.1	111.6 ± 96.0
FBS (mg/dl)	85.53 ± 17.16	91.36 ± 7.10	92.39 ± 8.61
AST (IU/l)	19.11 ± 4.01	21.92 ± 6.53	24.31 ± 7.80#
ALT (IU/l)	14.69 ± 7.42	26.86 ± 15.48*	24.50 ± 10.57*
γ-GTP (IU/l)	19.36 ± 9.01	36.03 ± 29.60#	38.14 ± 38.44#

BMI: Body mass index; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; FBS: Fasting blood sugar; AST: Aspartate aminotransferase; ALT: Alanine aminotransferase (IU/l); γ-GTP; γ-glutamyl transpeptidase, Data are mean ± standard deviation values.

Significant: *, $P < 0.001$ #, $P < 0.05$., as compared with Term A by repeated measures ANOVA.

C. Blood sugar levels also showed a tendency for higher levels in Terms B and C. The values for ALT and γ-GTP were increased significantly in Terms B and C compared to Term A. The values for AST increased significantly in Term C as compared with Term A.

Changing Type of Job and Lifestyle Habits

Lifestyle habits of the workers in the manufacturing department (Term A) were significantly different from those of workers in the sales (Term B) (Table 2), with increase in alcohol and tobacco consumption and a tendency for decrease of sleep hours.

Four of 9 workers with liver dysfunction in Term B showed increased consumption of alcohol drinking. The volume of alcohol intake in these cases, however, was not assumed to be the cause of the liver dysfunction.

Accumulation of Metabolic Syndrome Components during Job Transfer

Five of the 36 subjects in the present study showed two or more components of the metabolic syndrome in Term A (Table 3, Group I). Seven workers developed two or components in sales although they had zero to one component before the job transfer (Group II). Three workers showed two components in Term C, but not in Terms A and B (Group III). The remaining 21 workers had 0 to one component throughout the observation period (Group IV).

Changing Type of Job and Metabolic Syndrome Components Related to Elevated Liver Enzymes

The values of AST, ALT, and γ-GTP were increased in Terms B and C (Table 1). No subject showed elevated liver enzymes before the job transfer, but 9 new cases (25%) were seen in Term B; three of them recovered and 4 new cases appeared in Term C (Table 3). They were negative for HBV and HCV markers, and fatty infiltration of the liver

Table 2. Comparison of life style habits

N = 36	A: Manufacturing	B: Sales	C: Manufacturing
Alcohol intake (g/week)	119.9 ± 153.1	328.9 ± 213.4*	149.4 ± 148.4
Cigarette (number/day)	12.8 ± 11.0	21.9 ± 16.3#	15.4 ± 11.26
Work hours (day)	8.66 ± 0.85	11.08 ± 2.37$	—
Sleep hours (day)	7.07 ± 2.07	6.67 ± 2.29	—

Data are mean ± standard deviation values.
* $P < 0.001$ v the values for terms A and C by repeated measures ANOVA.
\# $P < 0.05$ v the value for term A by repeated measures ANOVA.
$ $P < 0.001$ by paired t test.

Table 3. Accumulation of metabolic syndrome components

Group	No.	age	Term A	Term B	Term C
I	10	42	2	1	1
	25	30	3	3+	3+
	26	29	2	2	3
	27	29	2	2	2
	40	31	2	3+	3+
II	6	45	1	3	2
	12	34	0	2	0
	14	31	1	3+	1+
	22	30	0	2+	2
	31	26	1	2+	0
	37	26	1	2+	0+
	39	26	1	3+	2
III	3	47	0	1	2+
	5	46	0	1+	2+
	13	34	1	0	2+
IV	1	53	0	0	0
	4	48	1	1+	0+
IV continued	7	41	1	1	1
	8	39	1	1	1
	11	35	0	0	1
	15	31	1	0	0
	16	31	0	1	0
	17	31	0	0	0
	18	34	0	1	0
	19	30	0	0	0
	23	30	1	1	1
	24	30	1	0	1
	28	27	0	0	0
	29	26	0	0	0
	30	26	0	0	1
	32	25	0	0	0
	33	25	0	1	0
	34	25	0	0	0+
	35	25	0	0	0
	36	25	0	0	0+
	38	26	1	0	0

+ : with elevated liver enzymes

was confirmed by ultrasonography. Other liver diseases such as autoimmune hepatitis, drug-induced hepatitis and known metabolic disorders were excluded by further serological tests. To investigate links with the metabolic syndrome, we compared the frequency of liver dysfunction between Groups II and IV using the Fisher's exact test. In Group II, 5 of 7 workers had liver dysfunction, while this was the case for only one of 21 workers in Group IV (P=0.001).

Comparison of JCQ Scores between Term I and Term II

Decision Latitude scores increased significantly after the workers moved from manufacturing to sales, and Job Demand scores decreased significantly, although, no difference were observed between Groups II and IV. There was no difference in Social Support scores during the same period (Table 4). As to Decision Latitude, both "skill discretion" and "decision authority" scores increased significantly when workers moved to the sales department. Although no significant difference was seen for Social Support during this period, "supervisor support" scores decreased significantly after the workers moved to sales.

With the simple alternative questionnaire, 28 out of 36 workers (77.8%) felt stress in the working Term B.

Factors Associated with Accumulation of Metabolic Syndrome by Logistic Regression Analysis

In the present study, 11 out of 36 workers had two or more components of the metabolic syndrome at the end of Term B. To clarify the factors associated with accumulation of components in Term B, logistic regression analysis was performed with variables including age, smoking (number of cigarettes/day) and drinking (ethanol consumption/week) habits, score of Karasek's Questionnaire at Term II, sleep and work hours, and ALT values. All the independent variables were continuous variable. Among these factors ALT was significantly positively associated with an increase in risk of the metabolic syndrome, whereas an inverse relationship was noted for sleep hours (Table 5).

Table 4. Comparison of JCQ scores

N=36	A: Manufacturing	B: Sales
Decision Latitude	57.6±7.7	74.9±10.6*
Skill discretion	30.1±5.1	36.5±6.1*
Decision authority	27.4±6.9	38.4±6.4*
Job Demand	32.8±5.3	30.2±6.5#
Social Support	22.2±2.6	21.7±4.4
Supervisor support	11.4±1.7	10.3±2.8#
Coworker support	10.8±1.4	11.4±2.2

Data are mean±standard deviation values.
Significant level: * $P<0.001$; # $P<0.05$ by paired t test.

Table 5. Factors associated with accumulation of the metabolic syndrome components at Term B

n=36

Independent variables	odds ratio	95% CI[1)]	p value
Age (years old)	1.108	0.940–1.307	0.223
Drinking (consumption of ethanol/week)	1.001	0.995–1.007	0.717
Smoking (number of cigarettes/day)	0.991	0.925–1.062	0.795
Sleep (hours/day)	0.382	0.161–0.905	0.029
Work hour (hours/day)	0.763	0.440–1.321	0.334
Decision latitude	1.067	0.935–1.217	0.339
Job demand	0.950	0.813–1.110	0.518
Social support	1.099	0.855–1.411	0.462
ALT (IU/l)	1.150	1.024–1.291	0.018

Forced entry: All variables entered in a single step.
Hosmer and Lemeshow Goodness-of-Fit Test: P=0.513 (chi-square=6.231, df=7).
1) Confidence interval.

IV. Discussion

In the present study, job transfer from car-manufacturing to car-sales and back to manufacturing caused significant changes in lifestyle with regard to alcohol intake, smoking, and sleeping hours. The remarkable increase in the number of persons having metabolic syndrome components at the end of Term B is exceedingly interesting in this regard (Table 3). We supposed job stress to be one of the causes but the results of Karasek's JCQ scores, however, did not show any increase in Job Demand, nor decrease in Decision Latitude or Social Support (Table 4). The results are contrary to our expectation because usually increase in Decision Latitude by Karasek's JCQ is thought to be a less stressful condition. However, 77.8% of workers transferred to sales answered that working became more stressful. These two opposite results indicate that changes in the Karasek's JCQ score do not necessarily reflect stressful situations. It should be noted that the Karasek's JCQ does not include skill underutilization and evaluation of individual work.

There have been 6 previous reports describing relationships between the metabolic syndrome and stress from our search of the literature. Vitaliano et al. described that in older men, pathways occur from chronic stress to distress to the metabolic syndrome, which in turn predicts chronic heart disease[9]. Kang et al. reported prevalences of metabolic syndrome in the lower strain group and high strain group of 13.2% and 23.8%, respectively[2] and Black presented the hypothesis that repeated episodes of acute or chronic psychological stress can induce an acute phase response and inflammation which is associated with certain metabolic syndromes[10]. Brostedt et al. described that job strain might affect the risk of coronary heart disease by influencing important elements of the cardiovascular system[11]. Raikkonen et al. examined the association between psychosocial stress-related variables and insulin resistance syndrome risk factors, and found tiredness, type A behavior, hostility, and anger to be significantly correlated with hyperinsulinemia, hyperglycemia, dyslipidemia, hypertension, and increased abdominal obesity[3]. Rosmond has stated that chronic increase in catecholamines and cortisol caused by environmental stress may lead to the metabolic syndrome[1]. In the present study, we could not confirm the workers to be under high strain during Term B. However, sleep hours were reduced. This and other sensitive indicators for the detection of stressful situations in job-transferred workers should receive further attention.

The present comparison between 7 cases with increased metabolic syndrome components in car-sales (Group II) and the 21 cases of Group IV disclosed no difference in change of jobs stress conditions with the Karasek's JCQ and simple stress questionnaires, as well as no differences in changes of smoking and drinking habits. In the present study, we did not have data on physical exercise and diet, which might have important effects. Genetic factors may also be involved in development of metabolic syndrome. We have investigated genetic polymorphisms of alcohol dehydrogenase 2 and the β3-adrenergic receptor (β3-AR) in 148 workers undergoing 35 year-old periodical health checks by law and found a close association with gene polymorphisms of both genes and elevation of liver enzymes[12].

When a patient with hypertension has dyslipidemia and impaired glucose tolerance, the risk of coronary heart disease was found to increase 3 to 8 times compared to the case with hypertension alone in the Framingham study[13]. Accumulation of risk factors by individuals has been named as "syndrome X" by Reaven[14], "the deadly quartette" by Kaplan[15], and the "insulin resistance syndrome", proposed by DeFronzo[16]. Insulin resistance and accumulation of visceral fat are common characteristics and a "Definition and Criteria of Metabolic Syndrome" have been determined by Japanese Expert Committee, emphasizing indispensable elements[17]. As visceral obesity would be expected to precede insulin resistance theoretically, the importance of its detection needs to be stressed for prevention of the metabolic syndrome.

The criteria used in the present study are not the same as those of the Japanese Expert Committee, but included the principles of the metabolic syndrome, that is, obesity, hypertension, dyslipidemia and glucose intolerance, accepted internationally. There is still debate as to the most reliable cut-off point for waist circumference.

We observed many workers with elevated liver enzymes who had neither HBV nor HCV markers, and neither history nor signs and symptoms suggesting drug-induced liver injury or autoimmune liver diseases. Many of these workers thus appear to have had non alcoholic liver disease (NAFLD)[12], which recent evidence shows to be a manifestation of the metabolic syndrome[18]. Environmental change, like changes in job and lifestyle can cause obesity, dyslipidemia, hypertension, impaired glucose tolerance and elevation of liver enzymes. Our previous reports[4,5] did not include the third periodical health check data at Term C, and in the present study, elevated ATL was associated with having two or more metabolic syndrome components in Term B. As workers with elevated ATL without a certified etiology are usually observed at workplace checkups as having NAFLD[19], our results emphasize the importance of elevated ALT in relation to detection of the metabolic syndrome.

From our present data, beside ALT, sleep hours appear to be associated with reduction in the risk of metabolic syndrome. We also need more sensitive stress indicators for workers who work irregular hours to clarify the relationship between stress and the metabolic syndrome.

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