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Comparison of Cardiovascular Risk Profile Clusters Among Industrial Workers

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Purpose. The purpose of this study was to identify subgroups of the physical and behavioral risk profiles for cardiovascular disease among industrial workers, and to examine predicting factors for the subgroups.

Sample and Method. Health records of 2,616 male and female workers aged 19-56 years who were employed in an airplane manufacturing industry were analyzed. Data were analyzed using the Latent class cluster analysis.

Results. Four different clusters (two high-risk groups, one low-risk group, and one normal group) were found and these clusters were significantly different by age, gender, and work type ($p < .05$). The two high-risk groups had higher chances of drinking alcohol, elevated BMI, FBS, total cholesterol, having hypertension, and were significantly older, and had relatively high chances of being day workers rather than other groups. The low-risk group had higher chances of drinking alcohol, higher BMI and total cholesterols compared to normal group, and highest portions of current smokers and shift workers in the four clusters and their mean BP was within prehypertension criteria.

Conclusion. Industrial nurses should guide the lifestyle behaviors and risk factors of the high risk groups for CVD and need to intervene early for behavioral change for the low-risk group who are young and shift workers. Age, and work environment should be considered in planning for targeted preventive interventions for industrial workers.

Key Words : Cardiovascular disease, Risk factors, Industry, Workers

INTRODUCTION

Total cardiovascular diseases (CVD), including heart diseases and cerebrovascular diseases, are the second leading cause of death for 2003 in Korea (Korea National Statistical Office, 2004). The chronic nature of those diseases has led to poor quality of life, with accelerated medical expenses (Korean Institute for Health and Social Affairs, 2002). Especially, the mortality rate of ischemic heart disease has rapidly increased more than twofold, from 12.6/100,000 in 1994 to 26.3/100,000 in 2004 (Korea National Statistical Office, 2004).

CVD has also been ranked first among the causes of death of industrial accidents in Korea since 2001 (Korean Occupational Safety and Health Agency, 2003). CVDs have accounted for 47.2% of applications for survivors' benefits filed with the Korea Labor Welfare Corporation since 1990. About 64% of employees who suddenly died had their deaths attributed to hypertension, followed by hypercholesterolemia and hyperglycemia, highlighting the desperate need for prevention and management of those diseases (Korean Occupational Safety and Health Agency, 2003).

CVD is a multifactor process that is contributed to by

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a variety of biological and behavioral characteristics of the person. Hypertension, hyperglycemia, and hypercholesterolemia may contribute to the incidence of CVD by increasing the risk for arteriosclerosis, and they are closely related to lifestyle behavior patterns. Personal health habits such as not smoking, reducing drinking, eating a balanced diet, exercising regularly, controlling stress, and losing weight can be considered positive health-promoting behaviors, and these interventions could be provided by nurses effectively (Haskell, 2003).

Latent class cluster analysis was used to identify and classify the case subtypes (latent classes) of the subjects' responses (Vermunt & Magidson, 2000). In latent class cluster analysis, an individual's posterior class-membership probabilities are computed from the estimated model parameters and the observed scores . It is a statistical model-based approach that has important differences from standard cluster analysis techniques like K-means implemented in the SPSS (Vermunt & Magidson, 2002). The advantages of using a statistical model are that the choice of the cluster criterion is less arbitrary and it is relatively easy to deal with variables of mixed scale types for categorical and continuous variables (Vermunt & Magidson, 2002).

Previous research on industrial workers has focused on the risk factors of hypertension and the relationship between hypertension and cardiovascular risk factors (Lee et al., 2002; Lee, Choi, Lee, Bae, &Lee, 2000). Also, most clinical or educational guidelines in the industry focus primarily on the management of individual CVD risk factors, such as high blood pressure, hypercholesterolemia, or diabetes (Lee et al., 2002; Lee et al., 2000). However, a study suggested replacing the single risk factor-based approach with the assessment of comprehensive CVD risk in the individual's management (Volpe et al., 2004). Hence, a more appropriate approach would be needed to reduce CVD risk by comprehensive evaluation of risk profile in individuals, including health behaviors or work environment. Therefore, clustering of workers' health behaviors and risk profiles could help to understand workers' health state comprehensively and to identify risk groups for CVD to develop targeted interventions for the groups.

RESEARCH METHOD

Research design

This study is a cross-sectional descriptive study using health records of industrial workers. The research questions are whether, on the basis of workers' physical health data, it is possible to identify subgroups that differ with respect to the likelihood of success of education about CVD risk factors, and what demographic variables predict the difference of the subgroups.

Samples

The health records of 2,616 workers at two airplane maintenance factories located at a southern metropolitan area in South Korea were selected from the 2002 biennial physical examination. The eligibility criteria included men and women at all ages with no known disease and those who worked full-time. Excluded were the workers who were on medication for hypertension, high cholesterol, or diabetes (n = 84).

Instrument

The health survey questionnaire had 10 items related to hypertension and related lifestyle questions and demographic items. Questions included the frequency and amount of time a day spent in drinking and smoking, the frequency of exercise that produced sweat, and the stress that can result in feeling tired or overwhelmed. Laboratory values such as serum fasting blood glucose and total cholesterol were measured by nurses. In addition, height, weight, and blood pressure were measured, and obesity index (BMI) was calculated, and subjects' age and working position were recorded.

Data collection

Data were collected from October 2 to December 20, 2002 during the biennial employee physical checkup time. Approval for this study was obtained from a representative of the company. Subjects completed the health survey questionnaire, and an experienced Health Unit nurse measured subjects' height, weight, and blood pressure, and calculated body mass index (BMI). She also drew blood samples for glucose and cholesterol, and the values were measured by a certified laboratory technician at the company's laboratory. Blood pressure was checked once on the left brachial artery by using an electronic blood pressure sphygmomanometer (UA-732, made in Japan) after 20 minutes' rest in sitting position. If the blood pressure was higher than 140/90 mmHg at the first measure, it was rechecked by using a Yamasu mercury sphygmomanometer and Littmann Classic stethoscope after 10 minutes' rest.

A fasting blood sugar (FBS) sample was collected from the brachial vein by using a 21×1 1/2" Vacuette needle and Vacuette gel in a clot activator tube and was analyzed by using Cobas Integra 400 in a laboratory room. Total cholesterol was measured by a colorimeter method using the visibility range of the cholesterol oxidase enzyme method (520 nm). Body mass index (BMI) is a value calculated by: weight in Kg/[height in m]2. Height was checked to 0.1 cm by a scaled height machine made by Samhwa Mechanical Ltd. and weight to 0.1 Kg by a scaled weighing machine made by Kyungin Mechanical Ltd.

Data analysis

Data were analyzed using latent class clustering with Latent GOLD version 3.0 statistical package (Vermunt & Magidson, 2003). The four categorical indicators were drinking (4 levels), smoking (3 levels), exercise (4 levels), and stress (4 levels), and the five continuous indicators were BMI, FBS, total cholesterol, systolic blood pressure, and diastolic blood pressure. The categorical variables were treated as nominal, and the continuous variables would be assumed to have normal distribution with class-specific variances, and these 9 indicators were included in model parameters estimation. To determine the number of classes, diagnostic indices like BIC (Bayesian Information Criterion) and AIC (Akaike Information Criterion) based on chi-squared statistic that is the most popular set of model selection tools in LC cluster analysis select model (Fraley and Raftery, 1998) were used. For these indices, smaller values correspond to more parsimonious models (Vermunt & Magidson, 2000). The demographic variables of age, work section, and gender were selected and used as covariates to identify the difference between classes. As an option of the LC cluster analysis, covariates can be selected for the analysis to describe or predict (rather than to define or measure) the latent variable (Vermunt & Magidson, 2000).

RESULTS

General characteristics of the sample

The mean age of subjects was 36.9±7.4 years (range 19-56), and 47.6% of the subjects were 30-39 years, 35.8% were 40-56 years, and 16.6% 19-29 years. The majority of the sample (94.6%, n = 2,476) were male workers. Forty-four percent of subjects worked in the manufacturing section, 31.3% in the repair section, 14.4% in the management section, and 10% in the service or sales section. Workers in the manufacturing and the repair sections were usually two-shift or three-shift rotating workers doing physical activity and collectively called shift workers in this paper; those in the other two categories are referred to as day office workers.

About 36% of the subjects (n = 951) indicated that they were drinking alcohol more than 1-2 times a week, and 59% of the subjects (n = 1,542) answered that they were drinking more than 1 bottle of SOJU (a favorite Korean beverage) at a time. In the case of smoking status, about 47% of the subjects (n = 1,225) indicated that they smoke currently, and 16.1% smoked in the past but have stopped. Of those who smoke currently, the majority (72%, n = 880) answered that they were smoking more than a half pack through 1 pack a day, and 4% smoked 1-2 packs a day (n = 109). About 64% of the sample (n = 1,685) indicated that they exercised enough to make them sweat at least once a week and 23.7% of the subjects (n = 619) answered that they felt overwhelming psychological stress that made them physically tired sometimes or often in the recent a week.

The mean BMI was 23.2±7.4; 79.5% of the subjects were within the normal range, and 20.5% (n = 537) were overweight or obese (BMI ≥25.0). The mean fasting blood glucose was 92.9±13.0 mg/dl, and 2.5% of the sample (n = 64) showed hyperglycemia (≥121 mg/dl). The mean cholesterol of the sample was 192.4± 33.3 mg/dl, and 37.1% of the sample (n = 971) showed an abnormal total cholesterol level greater than 200 mg/dl. The mean systolic blood pressure of the subjects was 120.2±14.1 mmHg (range 81-198) and the mean diastolic blood pressure was 78.3±11.1 mmHg (range 43-130). The 14.1% of the subjects (n = 369) were classified to hypertension (systolic BP ≥140 mmHg or diastolic BP ≥90 mmHg), 44.6% (n = 1,167) to prehypertension (systolic BP between 120 and 139 mmHg or diastolic BP between 80 and 89 mmHg), and 41.3% were within the normal range. Demographic characteristics are shown in Table 1.

Latent class cluster analysis

When BIC values of each class model were compared, the lowest value occurred for the 5-class model and began to rise in the 6-class model. The AIC value continued to decline but the decrease in these fit statistics was minimal between a 4-class and 5-class model. However, when the reduction rates of BIC values from the base-

Table 1. Characteristics of the Study Sample

Characteristics		N = 2,616	%
Age	19–29 years	434	16.6
	30–39 years	1,245	47.6
	40–49 years	774	29.6
	50–56 years	163	6.2
	M±SD: 36.9±7.4		
Gender	Female	140	5.4
	Male	2,476	94.6
Working Section	Management	378	14.4
	Manufacturing	1,155	44.2
	Repair	818	31.3
	Service/Sales	265	10.1
Drinking Alcohol	None	685	26.1
	2–3 times/month	980	37.5
	1–2 times/week	821	31.4
	≥3 times/week	130	5.0
Smoking	None	970	37.1
	Smoked but quit	421	16.1
	Currently smoke	1,225	46.8
Exercise	None	931	35.6
	1–2 times/week	1,249	47.7
	≥3times/week	436	16.6
Emotional Stress	None or Not sure	1,997	76.4
	Sometimes	570	21.8
	Often	49	1.9
Body Mass Index (kg/m^2)	15.4–24.9	2,079	79.5
	25.0–29.9	520	19.9
	30.0–33.9	17	0.6
	M±SD: 23.2±7.4		
Fasting Blood Sugar (mg/dl)	62–120	2,552	97.5
	121–262	64	2.5
	M±SD: 92.9±13.0		
Total Cholesterol (mg/dl)	103–200	1,645	62.9
	201–239	751	28.7
	240–259	133	5.1
	260–358	87	3.3
	M±SD: 192.4±33.3		
Systolic Blood Pressure (mmHg)	81–119	1,321	50.5
	120–139	984	37.6
	140–198	311	11.9
	M±SD: 120.2±14.1		
Diastolic Blood Pressure (mmHg)	43–79	1,465	56.0
	80–89	753	28.8
	90–130	398	15.2
	M±SD: 78.3±11.1		
Blood Pressure Group	Normal < 120/80	1,080	41.3
	Prehypertension 120–139 or 80-89	1,167	44.6
	Hypertension ≥140 or ≥90	369	14.1

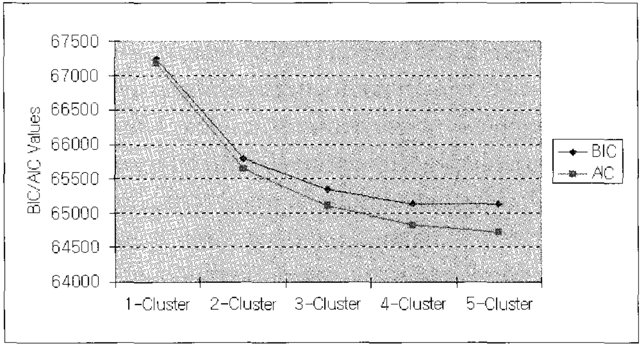

Figure 1. Model classes and changes of diagnostic indices values.

line BIC in each model were compared, the smallest reduction was found in the 4-class (65,158) and 5-class model (65,143). Thus, the 4-class model was determined to be the best model fit. Figure 1 shows the change of BIC and AIC values according to each class model.

Table 2 shows the size of each class and the profile of cardiovascular risk factors in the classes. Wald statistics that are provided by default to assess the statistical significance of the set of parameter estimates associated with a given variables showed that all 9 indicators were significantly different between classes at a $p = .01$ level. This means that the four classes are distinctly different. Overall, two high-risk groups (17.4%, n = 456), one low-risk group (48.6%, n = 1,271), and a healthy group (34.0%, n = 889) were identified.

The subjects in Clusters 3 and 4 respectively had a 41.1% and 42.9% chance of drinking ≥1-2 times a week with more than a bottle of drink. This is relatively similar to Cluster1 (40.7%) but significantly higher than Cluster 2 (27.5%). Cluster 3 (39.1%) and Cluster 4 (33.8%) had higher class membership probabilities of having obesity (≥BMI 25.0) compared to other two groups. Blood tests showed that the most hyperglycemic study subjects (≥FBS 121 mg/dl) (93%, n = 59/64) belonged to Cluster 4. The chances of having high cholesterolemia (≥201 mg/dl) were also highest in Cluster 4 (56%), followed by Cluster 3 (48%). When blood pressure was compared, the subjects in Cluster 3 had noticeably higher chances of having ≥140 mmHg systolic (63%) and ≥90 mmHg diastolic blood pressure (79%) than those of Cluster 4 (47% and 43%). The subjects in Cluster 3 had the highest mean blood pressure (M = 142/95 mmHg), representing hypertension, followed by Cluster 4 (M = 138/88 mmHg), representing prehypertension. These two clusters could be named as high-risk groups for CVD.

The subjects in Cluster 1, the largest cluster (48.6%, n = 1,271) had a 41% chance of drinking more than 1-2 times per a week and more than a bottle of SOJU at a time, and had the highest chance of smoking (50%) currently compared to the other three clusters. Of those, 67.3% exercised enough to make them sweat more than 1-2 times a week, and 23.3% felt emotionally severe stress in a recent week. Twenty-four percent of them were obese (≥BMI 25), and it was meaningfully higher than in the healthy group of cluster 2 (6.4%). Cluster 1 subjects had a 41% chance of having elevated cholesterol (≥201 mg/dl), and 64.8% and 54.5% chances of having elevated blood pressure (≥120 mmHg systolic and ≥80 mmHg diastolic), respectively. The blood pressures of the majority were within the prehypertension range.

The subjects in Cluster 2 had distinctly lower chances of drinking and having obesity compared to the other three clusters. However, this healthy group had high

Table 2. Clusters of Cardiovascular Risk Profiles in the Study Subjects

Cluster size		Cluster 1 48.6% n = 1,271 (%)	Cluster 2 34.0% n = 889 (%)	Cluster 3 14.5% n = 379 (%)	Cluster 4 2.9% n = 77 (%)
	Total n = 2,616				
Drinking Alcohol					
	≥3-4 times/week	74 (5.8)	28 (3.1)	22 (5.7)	6 (7.8)
	1-2 times/week	443 (34.9)	217 (24.4)	134 (35.4)	27 (35.1)
	< 1-2 times/week	754 (59.3)	644 (72.5)	223 (58.9)	44 (57.2)
Smoking					
	Current smoker	636 (50.0)	403 (45.3)	149 (39.3)	37 (48.1)
	Smoked but quit	222 (17.5)	111 (12.5)	76 (20.1)	12 (15.6)
	Never smoked	413 (32.5)	375 (42.2)	154 (40.6)	28 (36.4)
Exercise					
	None	415 (32.7)	398 (44.8)	100 (26.4)	18 (23.4)
	1-2 times/week	633 (49.8)	381 (42.9)	196 (51.7)	39 (50.6)
	≥3-4 times/week	223 (17.5)	110 (12.3)	83 (21.9)	20 (26.0)
Stress					
	Often/sometimes	295 (23.3)	246 (27.7)	62 (16.3)	16 (20.8)
	None or not sure	976 (76.4)	643 (72.3)	317 (83.7)	61 (79.2)
Body Mass Index					
	25.0-33.9 kg/m^2	306 (24.1)	57 (6.4)	148 (39.1)	26 (33.8)
	16.2-24.9 kg/m^2	965 (75.9)	833 (93.6)	231 (60.9)	51 (66.2)
	M±SD	23.6±2.1	21.8±2.1	24.5±2.5	24.2±2.5
Fasting Blood Sugar					
	121-262 mg/dl	2 (0.2)	0 (0.0)	3 (0.8)	59 (76.6)
	62-120 mg/dl	1269 (99.8)	889 (100.0)	376 (99.2)	18 (23.4)
	M±SD	93.0±8.7	87.6±7.5	96.2±9.5	135.3±34.7
Total Cholesterol					
	240-358 mg/dl	124 (9.8)	31 (3.4)	51 (13.5)	12 (15.6)
	201-239 mg/dl	397 (31.2)	172 (19.4)	131 (34.5)	31 (40.2)
	≥ 200 mg/dl	750 (59.0)	686 (77.2)	197 (52.0)	34 (44.2)
	M±SD	196.4±32.6	180.4±29.3	203.4±35.1	209.4±35.2
Systolic Blood Pressure					
	≥140 mmHg	36 (2.8)	0 (0.0)	239 (63.1)	36 (46.8)
	120-139 mmHg	788 (62.0)	44 (4.3)	140 (36.9)	19 (24.6)
	< 120 mmHg	447 (35.2)	845 (95.7)	0 (0.0)	22 (28.6)
	M±SD	123.6±8.2	107.1±7.1	141.8±8.8	137.8±28.1
Diastolic Blood Pressure					
	≥90 mmHg	68 (5.3)	0 (0.0)	298 (78.6)	33 (42.9)
	80-89 mmHg	625 (49.2)	29 (3.2)	75 (19.8)	21 (27.9)
	< 80 mmHg	578 (45.5)	860 (96.8)	6 (1.6)	23 (29.9)
	M±SD	80.7±6.0	68.3±6.0	94.7±7.2	87.6±17.0

chances of smoking currently (45.3%), having non-exercisers (44.8%), and having emotional stress (27.7%). Blood tests also showed that these two clusters had minimal chances of having high FBS and having high total cholesterol (either ≥201 or ≥240 mg/dl), when compared with other clusters. The mean systolic and diastolic blood pressures were also within normal range.

To predict class membership probabilities of observed response variables, the three covariates of age, gender, and work type were included in model parameter estimation (Table 3). The subjects in Cluster 3 and Cluster 4 had higher chances of having older-aged workers than the other two clusters. Cluster 2 subjects were the youngest, and the majority of female subjects (n=117/140, 84%), who work mostly in the service or sales section, were included in this cluster. Day workers who do not work on a shift basis were a relatively higher portion in Cluster 3 (27%) and Cluster 4 (31%), while shift workers were high in Cluster 1 (80%). The 51.5% of two- or three-shift rotating shift workers in the study (n = 1,018/1,973) belonged to Cluster 1. All three covariates predicted significantly the different class membership of the four clusters ($p < .05$).

DISCUSSION

By latent class clustering, four distinct clusters were identified from the workers' health data. Of those, two clusters could be defined as high-risk groups for CVD. The subjects of the two clusters had higher chances of having elevated BMI and of having elevated cholesterol, FBS, and systolic and diastolic blood pressure compared to the other clusters. The mean blood pressure of Cluster 4 subjects was lower than that of Cluster 3 subjects, but 92.2% (n=59/ 64) of all hyperglycemic subjects in this study were included in Cluster 4. Cluster 4 had more current smokers (48.1%) than Cluster 3(39.3%) and can be classified as a high-risk group as much as Cluster 3. It is assumed that the most hypertensive subjects (systolic ≥140 or diastolic ≥90) of this study (when the frequency was calculated, n = 367) could be included in these two clusters.

This high relevancy of hyperglycemia and hypertension was supported by previous studies showing that hypertension incidence was more than twice higher in a hyperglycemic group than in a normal glucose group (Lee, 1998; Lee, Choi, Shin & Park, 1994). Also, recent comprehensive reviews on the studies of patients with hypertension and diabetes reported that most diabetic patients developed hypertension within the first 10-15 years (Mancia, 2005; Ravid & Rachmani, 2005). The mean BP of Cluster 4 subjects was 138/88 mmHg and within the prehypertension range. A retrospective cohort study in the U.S. reported that the probability of diabetes was higher for persons with prehypertension compared to the normal BP group (Greenlund, Croff & Mensah, 2004). This indicates that Cluster 4 subjects (92.2% of whom had hyperglycemia) need to be referred or monitored closely for both diabetes and hypertension.

In this study, higher-class membership probabilities of being overweight or obese were found in the two high-risk clusters compared to the other groups. This is consistent with a study for male workers in an auto company, in which the prevalence of hypertension was 1.8 times higher in those with ≥BMI 25 than in those with

Table 3. Relationship between Class Memberships and Covariates

Covariates	Class 1 Mild Risk	Class 2 Normal	Class 3 High Risk	Class 4 High Risk	Wald	p
Age (M±SD)	36.7±7.0	35.5±7.0	39.3±8.0	43.7±7.2	101.4	<.000
19-39	832 (65.5)	634 (71.3)	194 (51.2)	19 (24.7)		
40-56	439 (34.5)	255 (28.7)	185 (48.8)	58 (75.3)		
Gender					22.8	<.001
Female	20 (1.6)	117 (13.2)	2 (0.5)	1 (1.3)		
Male	1251(98.4)	772 (86.8)	377 (99.5)	76 (98.7)		
Work type					7.8	.050
Shift work						
Manufacturing	601 (47.3)	352 (39.6)	173 (45.6)	29 (37.7)		
Repair	417 (32.8)	273 (30.7)	104 (27.4)	24 (31.2)		
Day work						
Management	158 (12.4)	134 (15.1)	66 (17.4)	20 (26.0)		
Service/Sales	95 (7.5)	130 (14.6)	36 (9.6)	4 (5.1)		

normal BMI (Lee et al., 2000). Also, recent studies for general men and women who are not industrial workers showed that increased BMI and waist circumference were significantly associated with hypertension (Lee, Kim, Sunwoo, & Huh, 2005; Sung & Ryu, 2004). Similarly, numerous research reports supported the positive correlation between obesity and hypertension (Berger, Bender, Trautner, Spraul, 1998; Lee et al., 1994; Moon, Jang, Yoon, & Kim, 1999). In addition, the subjects of Cluster 3 and Cluster 4 had higher-class membership probabilities of high cholesterolemia ($\geq$ 201 or $\geq$240 mg/dl) compared to the other clusters. This possible relationship between obesity and high cholesterolemia was supported by a study of industrial male workers that showed that obese workers ($\geq$BMI 25) were more likely to have high cholesterolemia at the younger age of 40 years (Lee et al., 2000). Therefore, industrial nurses should monitor obese workers to find factors affect on their obesity and need to manage them with effective approaches including health education and exercise program.

However, the two high-risk groups did not show higher probabilities of having behavioral risks such as smoking, less exercise, and emotional stress compared to the low-risk or normal groups. Current smokers were least in the Cluster 3 and the portions of exercisers in the high-risk groups were higher than the other two groups. Their mean age was older than 40 years of age, and they had a higher chance of having older age (40-56 years) compared to the other clusters. This means that, in spite of middle-aged workers trying to keep their bodies healthy, aging could make their bodies have troubles. Previous studies reported a significant association of age and hypertension (Lee et al., 2005; Sung & Ryu, 2004), and different risk factors for cardiovascular disease were found in greater amounts below 40 years of age (Lee et al., 2000). This suggests that we need to focus on targeted preventive measures for this middle-age group and developing effective interventions for them. Another explanation of this discrepancy or negative relationships of health behaviors and cardiovascular risk factors might be related to the non-comprehensive items to identify behavioral factors and under- or misreporting for the questions.

The subjects of Cluster 1 had higher membership probabilities of having elevated FBS, cholesterol, and BMI, and drinking alcohol and smoking currently compared to the normal group. Also, they had distinctly the highest chance of having prehypertension (systolic 120-139 mmHg or diastolic 80-89 mmHg) in the four clusters, and this cluster could be called a low-risk group. This is supported by a previous study showing that an elevated cholesterol level (> 200 mg/dl) was greater for persons with prehypertension compared to a normotension group (Greenlund et al., 2004). Cluster 1 also showed the highest portion of current smokers in the 4 clusters, but the relatively younger age may influence or mask their values of blood tests. Therefore, more individualized health education or interventions would be needed early for this low-risk group to prevent future health problems.

A normal group was found with comparably low chances of having physical and health behavioral risks, but they had a 45% chance of currently smoking and 45% chance of being non-exercisers, which is cause for concern. The work types or places may affect individuals' risk factors for cardiovascular disease. The chances of having shift-work were higher in Cluster 1 (low-risk group), followed by Cluster 3 (high-risk group), compared to the other groups. This is related to a 9-year cohort study that chronic noise exposure increased systolic blood pressure of industrial workers (Lee et al., 2002). Also, it was supported by a study that workers engaged in 3-shift rotation in chemical production had a higher prevalence of hypertension than those in the paper manufacturing sector in Japan (Inoue, Morita, Inagaki, & Harada, 2004). Besides hypertension, shift workers more than day workers had high triglyceride levels and low levels of HDL-cholesterol and abdominal obesity (Karlsson, Knutsson, Lindahl, & Alfredsson, 2003). Thus, to identify cardiovascular risk factors for industrial workers, we should consider their working environments and job types (e.g., on a shift basis or blue-collar jobs). In contrast, the chances of having day-work were higher in the two high-risk groups, and this is assumed to be related to aging.

This study ensured the need to understand workers' health state comprehensively and the need to develop targeted interventions for the risk groups to prevent CVD. Industrial nurses should develop interventions that are most likely to be effective for the groups in reducing CVD risk factors. Further research is suggested to explore the behavioral barriers of high risk group for CVD and to develop effective approaches like health education or exercise programs in the industry. Data for this study were collected from the employer's biennial health examination. Thus, the question items were simple and did not include comprehensive items to assess daily habits. There is a possibility of under-reporting in workers because of company policy that strictly prohibits smoking at work. These would be limitations of this study.

CONCLUSION

The groups at high risk for CVD had higher chances of drinking alcohol, elevated BMI, FBS, total cholesterol, high BP, and whose age was older compared to other groups. In addition, an early intervention for behavioral change is needed for the low-risk group whose BP was within the prehypertensive range and who were young, work on a shift basis, and have health behavioral risks. The risk behaviors and factors for CVD need to be guided by considering age and work environment by industrial nurses.

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