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Metabolic syndrome: Association between prevalence and risk at worksites

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ABSTRACT

This study, conducted at major Japanese companies, aimed to determine if asymptomatic workers in workplaces with a high prevalence of metabolic syndrome have a greater risk of developing metabolic syndrome. Data were obtained from the health records of 298,145 people, from 2011 to 2015. We collected data on the participants' age, sex, physical examinations, laboratory tests, and lifestyle behaviors. To test whether the risk of metabolic syndrome in asymptomatic workers differed between groups with a higher and lower prevalence in 2011, Cox proportional hazards regression model was performed, with the covariates being controlled for. The analysis showed that the risk of metabolic syndrome among asymptomatic workers in the high-prevalence group was about 1.1-fold elevated compared to those within the low-prevalence group. As a follow-up to these results, interventions aimed at asymptomatic workers should be provided in workplaces with a high prevalence of metabolic syndrome.

KEYWORDS
Japanese workers; metabolic syndrome; work environment

Background

In Japan, cardiovascular disease stemming from lifestyle diseases has become a significant health issue among the working-age population. In 2008, the Japanese government introduced a "system of specific health checkups" (*tokuteikenshin-seido*) – an annual physical examination including blood tests and a questionnaire on lifestyle behavior – for the prevention of lifestyle diseases. The target population of this system is citizens aged 40–74 years,[1] and the national average uptake rate of these checkups is now over 80%.

In Japan, the prevalence rate and risk of metabolic syndrome are high.[2] Metabolic syndrome refers to the condition in which, due to harmful health-related behaviors, fat has accumulated around the internal organs and, further, a person has developed dyslipidemia, high blood pressure, or diabetes. In addition to living habits, vocation may also be associated with the risk of metabolic syndrome.[3–10] A cross-sectional study in the United States (U.S.) showed that after adjusting for confounding factors related to sex, age, and health-related behaviors, the prevalence rates differed across 40 major U.S. occupational groups.[3] A study of male civil servants in Germany suggested that the prevalence rates and risk of cardiovascular disease were higher among office workers and policemen than among firemen.[5–7] Further, the results of another study of employees in small- to mid-sized companies in Japan showed that the standard prevalence rates of metabolic syndrome differed among 18 business categories.[4] In other studies, the prevalence of metabolic syndrome was different among white-collar workers and blue-collar workers.[8–10]

These studies suggest that the work environment characteristic to each business category may be an underlying factor in the incidence of metabolic syndrome. Differences in the working conditions or type of work may affect an individual's health. For example, while several studies showed that the prevalence of metabolic syndrome was higher among people who worked night shifts,[11–18] others showed higher rates among people involved in sedentary desk work.[19–24] Thus, workplaces with a high prevalence of metabolic syndrome could increase healthy employees' risk for developing the disease. However, few studies have identified which working environments with high prevalence rates are associated with the

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Table 1. Criteria for the definition of metabolic syndrome.

Measure	Criteria
Abdominal obesity	
Waist circumference	≥85 cm (male), ≥90 cm (female)
BMI	≥25 kg/m^2
Risk factor (at least 1)	
Blood sugar	Fasting glucose ≥100 mg/dl or HbA1c ≥ 5.6%
Fat	Triglycerides ≥150 mg/dl or HDL cholesterol < 40 mg/dl
Blood pressure	≥130 mmHg systolic or ≥85 mmHg diastolic

Note. BMI = body mass index; HbA1c = glycated hemoglobin; HDL = high-density lipoprotein.

development of metabolic syndrome among asymptomatic workers.

We conducted a large sample of employees aged 40–74 years working at major Japanese companies, to evaluate if work environments with a high prevalence of metabolic syndrome increased the risk for this syndrome among asymptomatic workers. We hypothesized that asymptomatic workers in groups with a higher prevalence of metabolic syndrome at baseline would have a higher risk for developing this syndrome after five years, than would workers in groups with a lower baseline prevalence.

Methods

Study population

In Japan, approximately 1,400 company-sponsored insurance societies (*kenkōhoken kumiai*) existed at the end of 2015. For this study, we used the records of "specific health checkups" obtained from 33 large company-sponsored health insurance societies that agreed to participate. The business categories of the companies sponsoring the insurance societies included manufacturing, finance, retail sales, and transport. A total of 387,112 participants underwent specific health checkups in 2011 (baseline). After the elimination of data pertaining to insured members who did not undergo annual checkups in both 2011 and 2015, and were taking medication for high blood pressure, diabetes, or hyperlipidemia at the baseline, the data used for the analysis comprised records of 298,145 people.

Nationally, the average prevalence of metabolic syndrome (members diagnosed with or at a risk of developing it) in the employer-sponsored health insurance societies was 29.9% in 2011.[25] The prevalence of metabolic syndrome at baseline in each of the insurance societies participating in this study ranged from 15.0% to 39.4%. We categorized insurance societies with a prevalence rate higher than 29.9% as into a "high-prevalence group" ($N = 14$), and other societies into the 'low-prevalence group" ($N = 19$). The numbers of participants in the "high-prevalence group" and the "low-prevalence group" were 123,012 and 175,133, respectively.

Measurements

The criteria used in Japan's specific health checkup system to define metabolic syndrome are shown in Table 1. Individuals with a waist circumference or body mass index (BMI) at or over the values shown in Table 1 and with at least one of the blood sugar (fasting glucose or glycated hemoglobin (HbA1c)), fat (triglyceride or high-density lipoprotein (HDL) cholesterol level), or blood pressure (systolic or diastolic pressure) criteria were considered as having the metabolic syndrome in this study. The Japanese criteria for metabolic syndrome differ from those defined by the widely used World Health Organization (WHO), American Heart Association, and the International Diabetes Federation guidelines. The Japanese Society of Internal Medicine and other related academic societies formulated these criteria based on conditions prevailing in Japan, and the government has employed them since 2008.[26,27] In this analysis, we also used the results of questionnaire items related to lifestyle which were applied as part of the health checkups.

Statistical analysis

First, we summarized the descriptive statistics of the selected variables as per high- and low-prevalence groups. We aimed to test our hypothesis that asymptomatic workers in workplaces with a high prevalence of metabolic syndrome have a greater risk of developing metabolic syndrome. To this end, we calculated the correlation between metabolic syndrome prevalence in 2011 for the 33 insurance societies, as well as the number of people who were asymptomatic in 2011 and who became symptomatic in 2015. We also performed partial correlation analysis to control for potential confounding variables (percentage of men, and the average age of those in the insurance societies).

Table 2. Numbers and proportion of the study population at the baseline (2011) stratified by 'prevalence group' and divided according to the prevalence of metabolic syndrome in 2011 in the participating insurance societies – sex, age, business category, and health-related behaviors.

		High-prevalence group ($n = 14$)			Low-prevalence group ($n = 19$)			
		Total ($n = 123{,}012$)	Symptoms ($n = 40{,}312$)[b]	No symptoms ($n = 82{,}700$)	Total ($n = 175{,}133$)	Symptoms ($n = 40{,}316$)[b]	No symptoms ($n = 134{,}817$)	*p*-value[a]
Sex	Male	103,998 (84.5%)	38,083 (94.5%)	65,915 (79.7%)	135,165 (77.2%)	36,682 (91.0%)	98,483 (73.0%)	< .001
	Female	19,014 (15.5%)	2,229 (5.5%)	16,785 (20.3%)	39,968 (22.8%)	3,634 (9.0%)	36,334 (27.0%)	
Age (years)	40-49	85,658 (69.6%)	26,954 (66.9%)	58,704 (71.0%)	125,056 (71.4%)	27,359 (67.9%)	97,697 (72.5%)	≤ .001
	50-59	34,838 (28.3%)	12,419 (30.8%)	22,419 (27.1%)	48,311 (27.6%)	12,510 (31.0%)	35,801 (26.6%)	
	60-74	2,516 (2.0%)	939 (2.3%)	1,577 (1.9%)	1,766 (1.0%)	447 (1.1%)	1,319 (1.0%)	
Business category	Manufacturing	110,524 (89.8%)	36,097 (89.5%)	74,427 (90.0%)	120,185 (68.6%)	29,417 (73.0%)	90,768 (67.3%)	< .001
	Nonmanufacturing	12,488 (10.2%)	4,215 (10.5%)	8,273 (10.0%)	54,948 (31.4%)	10,899 (27.0%)	44,049 (32.7%)	
Smoking	Yes	38,559 (32.9%)	13,930 (36.3%)	24,629 (31.2%)	56,843 (32.5%)	14,329 (35.6%)	42,514 (31.6%)	.072
	No	78,817 (67.1%)	24,434 (63.7%)	54,383 (68.8%)	117,882 (67.5%)	25,908 (64.4%)	91,974 (68.4%)	
Alcohol consumption	No/Sometimes	87,263 (71.1%)	28,455 (70.8%)	58,808 (71.3%)	128,366 (73.3%)	29,591 (73.4%)	98,775 (73.3%)	< .001
	Every day	35,486 (28.9%)	11,760 (29.2%)	23,726 (28.7%)	46,721 (26.7%)	10,714 (26.6%)	36,007 (26.7%)	
Regular exercise[c]	Yes	19,002 (16.1%)	5,515 (14.2%)	13,487 (17.0%)	30,606 (17.5%)	6,647 (16.5%)	23,959 (17.8%)	< .001
	No	99,282 (83.9%)	33,208 (85.8%)	66,074 (83.0%)	144,509 (82.5%)	33,665 (83.5%)	110,844 (82.2%)	
Physical activity[d]	Yes	30,814 (26.1%)	9,367 (24.2%)	21,447 (27.0%)	47,966 (27.4%)	9,864 (24.5%)	38,102 (28.3%)	< .001
	No	87,459 (73.9%)	29,350 (75.8%)	58,109 (73.0%)	127,122 (72.6%)	30,444 (75.5%)	96,678 (71.7%)	
Walking speed[e]	Average/Slow	65,002 (55.0%)	22,532 (58.2%)	42,470 (53.4%)	99,663 (56.9%)	23,815 (59.1%)	75,848 (56.3%)	< .001
	Fast	53,269 (45.0%)	16,184 (41.8%)	37,085 (46.6%)	75,439 (43.1%)	16,496 (40.9%)	58,943 (43.7%)	
	Yes	58,414 (49.4%)	30,545 (78.9%)	27,869 (35.0%)	72,084 (41.2%)	30,848 (76.5%)	41,236 (30.6%)	< .001
≥10 kg weight gain from the age of 20	No	59,858 (50.6%)	8,175 (21.1%)	51,683 (65.0%)	103,024 (58.8%)	9,460 (23.5%)	93,564 (69.4%)	
≥ ±3 kg weight change within a year	Yes	43,448 (36.7%)	17,623 (45.5%)	25,825 (32.5%)	56,874 (32.5%)	16,854 (41.8%)	40,020 (29.7%)	< .001
	No	74,821 (63.3%)	21,095 (54.5%)	53,726 (67.5%)	118,159 (67.5%)	23,438 (58.2%)	94,721 (70.3%)	
Eating speed[f]	Average/Slow	85,719 (72.5%)	25,494 (65.8%)	60,225 (75.7%)	122,672 (70.1%)	24,450 (60.7%)	98,222 (72.9%)	< .001
	Fast	32,547 (27.5%)	13,223 (34.2%)	19,324 (24.3%)	52,447 (29.9%)	15,861 (39.3%)	36,586 (27.1%)	
Eat a meal within 2 h before bedtime	≥3 days/week	65,177 (55.1%)	22,968 (59.3%)	42,209 (53.1%)	96,110 (54.9%)	23,294 (57.8%)	72,816 (54.0%)	.242
	<3 days/week	53,097 (44.9%)	15,750 (40.7%)	37,347 (46.9%)	78,993 (45.1%)	17,017 (42.2%)	61,976 (46.0%)	
Have a late-night snack	≥3 days/week	32,807 (27.7%)	11,494 (29.7%)	21,313 (26.8%)	44,016 (25.1%)	10,428 (25.9%)	33,588 (24.9%)	< .001
	<3 days/week	85,465 (72.3%)	27,223 (70.3%)	58,242 (73.2%)	131,094 (74.9%)	29,879 (74.1%)	101,215 (75.1%)	
Skip breakfast	≥3 days/week	41,335 (34.9%)	14,683 (37.9%)	26,652 (33.5%)	54,688 (31.2%)	13,227 (32.8%)	41,461 (30.8%)	< .001
	<3 days/week	76,935 (65.1%)	24,035 (62.1%)	52,900 (66.5%)	120,430 (68.8%)	27,082 (67.2%)	93,348 (69.2%)	
Sleep sufficiency[g]	Sufficient	56,055 (47.4%)	18,041 (46.6%)	38,014 (47.8%)	83,683 (47.8%)	19,261 (47.8%)	64,422 (47.8%)	.029
	Insufficient	62,207 (52.6%)	20,673 (53.4%)	41,534 (52.2%)	91,350 (52.2%)	21,029 (52.2%)	70,321 (52.2%)	

[a]*p*-values were estimated through a Chi-square test performed between the total number of participants in the high-prevalence group and the total number of participants in the low-prevalence group. The degree of freedom was one for each Chi-square test for sex, business category, and health-related behaviors, and two for the Chi-square test for age.
[b]Symptoms = individuals meeting the definition of metabolic syndrome patients (Table 1) in 2011.
[c]In Japan's "specific health checkup system", *regular exercise* is defined as having exercised enough to break a light sweat for at least 30 minutes a day, twice a week, for at least a year.
[d]In Japan's "specific health checkup system", *physical activity* is defined as at least 1 hour a day of walking or comparable physical activities.
[e]In Japan's "specific health checkup system", *walking speed* is the relative speed as compared with the speed of others of comparable age and of the same sex, as judged by respondents subjectively.
[f]In Japan's "specific health checkup system", *eating speed* is relative speed compared with the eating speed of other individuals, as judged by respondents subjectively.
[g]In Japan's "specific health checkup system", *sleeping efficacy or having "sufficient" sleep* is defined as having enough rest from sleeping.

Subsequently, we performed the Cox proportional hazards regression model to estimate the association between the risk for metabolic syndrome, and differences between the at-risk groups, stratified according to sex. This was done after adjusting for confounding variables which included: age, business category (manufacturing or nonmanufacturing), the 2011 laboratory test results, physical examinations, answers relating to lifestyles from questionnaires conducted at health checkups (waist circumference, BMI, systolic/diastolic blood pressure, fasting, glucose, HbA1c, triglycerides, and HDL cholesterol), and the reported health-related behaviors in 2011 (smoking, alcohol consumption, regular exercise, physical activity, walking speed, ≥10 kg weight gain from age of 20, ≥ ± 3 kg weight change within a year, eating speed, eating a meal within 2 hours before bedtime, having a late-night snack, skipping breakfast, and sleep sufficiency). We categorized the results of the laboratory tests according to the Japanese health checkups criterion (Table 1). We have presented hazard ratios (HRs) for the variables, with 95% confidence intervals (CIs). We

Table 3. Mean values of the study population at the baseline (2011) stratified by 'prevalence group' and divided according to the prevalence of metabolic syndrome in 2011 in the participating insurance societies—laboratory tests and physical examinations.[a]

	High-prevalence group ($n = 14$)			Low-prevalence group ($n = 19$)			
	Total ($n = 123{,}012$)	Symptoms ($n = 40{,}312$)[c]	No symptoms ($n = 82{,}700$)	Total ($n = 175{,}133$)	Symptoms ($n = 40{,}316$)[c]	No symptoms ($n = 134{,}817$)	p-value[b]
Age (years)	46.9(46.89–46.95, 5.1)	46.9(46.88–46.98, 5.1)	46.9(46.88–46.95, 5.1)	46.9(46.91–46.96, 5.1)	46.9(46.86–46.96, 5.1)	46.9(46.91–46.97, 5.2)	.622
Waist circumference (cm)	82.7(82.66–82.76, 8.9)	91.4(91.37–91.49, 6.5)	78.5(78.42–78.51, 6.5)	81.0(81.00–81.09, 8.8)	91.2(91.15–91.28, 6.5)	78.0(77.96–78.03, 6.9)	< .001
BMI	23.3(23.25–23.29, 3.3)	26.3(26.31–26.36, 2.8)	21.8(21.77–21.80, 2.3)	22.8(22.79–22.82, 3.2)	26.4(26.40–26.46, 2.8)	21.7(21.71–21.74, 2.4)	< .001
Systolic pressure (mmHg)	119.1(119.03–119.20, 15.0)	125.7(125.54–125.83, 15)	115.9(115.82–116.01, 14.0)	119.5(119.39–119.54, 15.2)	128.3(128.16–128.46, 15.1)	116.8(116.74–116.9, 14.2)	< .001
Diastolic pressure (mmHg)	75.6(75.49–75.62, 11.3)	80.7(80.55–80.77, 11.1)	73.1(72.99–73.14, 10.4)	74.9(74.83–74.93, 11.3)	81.6(81.5–81.72, 11.1)	72.9(72.81–72.93, 10.5)	< .001
Fasting glucose (mg/dL)	97.2(97.07–97.25, 15.1)	102.8(102.58–102.98, 18.7)	94.4(94.28–94.45, 12.1)	93.3(93.23–93.37, 13.6)	99.6(99.43–99.81, 18.7)	91.4(91.35–91.47, 11.0)	< .001
HbA1c (%)	5.1(5.11–5.11, 0.5)	5.3(5.28–5.30, 0.7)	5.0(5.02–5.02, 0.4)	5.0(5.03–5.04, 0.5)	5.3(5.25–5.27, 0.7)	5.0(4.97–4.97, 0.4)	< .001
Triglycerides (mg/dL)	124.4(123.85–124.91, 95.1)	169.6(168.45–170.77, 118.7)	102.3(101.84–102.82, 71.4)	109.0(108.56–109.38, 87.8)	162.4(161.25–163.54, 116.9)	93.0(92.62–93.36, 69.4)	< .001
HDL cholesterol (mg/dL)	60.0(59.87–60.05, 15.8)	52.4(52.27–52.52, 12.7)	63.7(63.55–63.76, 15.9)	63.1(63.02–63.17, 16.3)	53.3(53.20–53.45, 12.8)	66.0(65.93–66.11, 16.1)	< .001

Note. BMI = body mass index; HbA1c = glycated hemoglobin; HDL = high-density lipoprotein. The values of waist circumference, BMI, systolic/diastolic pressure, fasting glucose, HbA1c, triglycerides, and HDL cholesterol are presented as the mean and standard deviation.

[a]Mean values are presented in this table. Values in the parenthesis are the upper and lower limits of the 95% confidence interval, as well as the standard deviation for the mean values. Because of the large sample size, a 95% confidence interval for mean values is very narrow. We show the 95% confidence interval at the second decimal place in the table.

[b]p-value estimated through a student's t-test performed between the baseline variables and the variables pertaining to the prevalence group (total).

[c]Symptoms = individuals meeting the definition of metabolic syndrome patients (Table 1) in 2011.

analyzed the records of 136,985 people who were asymptomatic in 2011, and who had completed data in their records to assess for variables by sex. IBM SPSS Statistics 23.0 (IBM Corp., Armonk, NY, USA) and STATA 14.0 (StataCorp LLC, TX, USA) were used for the statistical calculations.

Ethical considerations

This study was performed with the approval of the internal review board of the Institute and was completed in accordance with the Helsinki Declaration. For this study, informed consent was not required by Japanese law.

Results

The average age of each insurance society ranged from 45.0 to 48.6 years, and the number of participants in each society ranged from 348 to 62,925. The proportion of men in each society was between 21.2% and 89.9%. The data related to the baseline (2011) characteristics of the sample are shown by risk group in Tables 2 and 3. In the high-prevalence group, 82,700 of the 123,012 people (67.2%) and in the low-prevalence group 134,817 of the 175,133 people (77.0%) were asymptomatic for the metabolic syndrome. The low-prevalence group had a higher percentage of women than did the high-prevalence group (22.8% vs. 15.5%).

In the high-prevalence group, 11,757 (14.2%) participants without the metabolic syndrome at baseline developed the syndrome in 2015. In the low-prevalence group, 15,213 (11.3%) people had developed the metabolic syndrome in 2015. We observed a positive correlation between metabolic syndrome prevalence rate in 2011 and prevalence rates of workers who were asymptomatic in 2011 but became symptomatic in 2015, in all the participating insurance societies ($r = 0.784$, $p < .001$) (Figure 1). The correlation was significant after adjusting for the percentage of men and average age of those in the insurance societies ($r = 0.620$, $p < .001$) (Table 4).

The results of the Cox proportional hazards regression model analysis showed that the risks of metabolic syndrome within the high-prevalence group were 1.1-fold greater than that of the low-prevalence group for men (HR 1.10, 95% CI: 1.07–1.14), and 1.09-fold greater for women (HR 1.09, 95% CI: 1.00–1.18) (Table 5). "Waist circumference," "BMI," and "$\geq \pm 10$ kg weight gain from the age of 20" demonstrated the greatest risks amongst all of the

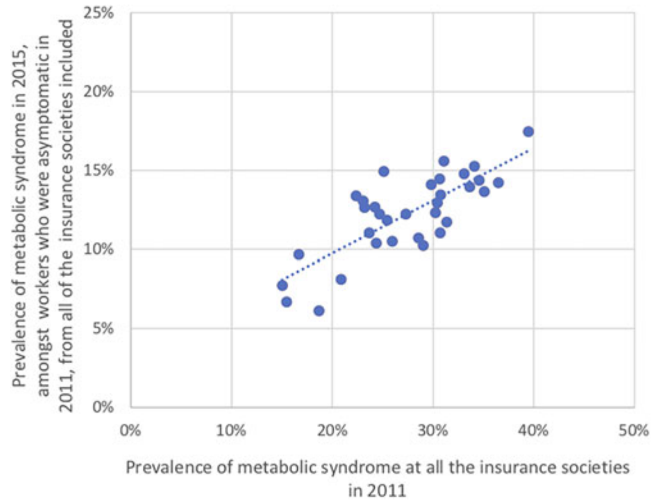

Figure 1. Correlation between the 2011 metabolic syndrome prevalence rate and the 2015 prevalence rates of workers who were asymptomatic in 2011 within the 33 insurance societies.

Table 4. Correlation coefficients between the 2011 metabolic syndrome prevalence rates in the 33 insurance societies, and the 2015 prevalence rates of those who were asymptomatic workers in 2011, in all of the insurance societies, adjusted for sex, age, and for both sex and age.

Partial correlation coefficient adjusted for various factors	Correlation coefficient	*p*-value
Sex	0.620	<.001
Age	0.786	<.001
Sex and age	0.620	<.001

covariates. Overall, the results of the physical examinations and laboratory tests showed larger HRs than those provided by the lifestyle questionnaires. Although the type of risks was identical for men and women, "HbA1c" was significant only for men, whereas "alcohol consumption" and "walking speed" were significant only for women. Men working in the "nonmanufacturing" industry have a smaller risk for developing metabolic syndrome (HR 0.89, 95% CI: 0.85–0.92), whereas women within that same industry have a larger risk (HR 1.21, 95% CI: 1.11–1.33).

Discussion

Our results suggested that, even after controlling for the effects of personal characteristics (age), laboratory tests and physical examinations (waist circumference, BMI, systolic/diastolic blood pressure, fasting glucose, HbA1c, triglycerides, and HDL cholesterol), health-related behaviors (smoking, alcohol consumption, regular exercise, eating speed, sleep sufficiency), and business category (manufacturing or nonmanufacturing), asymptomatic workers in the group with a higher metabolic syndrome prevalence rate at baseline had a higher risk of developing the syndrome than did workers in the group with a lower prevalence rate at baseline.

This study found that high-prevalence workplaces are associated with about a 1.1-fold higher risk of metabolic syndrome developing among their workers over time. The risk for metabolic syndrome development, associated with working in environments with a higher prevalence of the syndrome, was found to lie between the risk factors of eating quickly, and smoking. These results suggest that differences between workplaces in the study's high- and low-prevalence groups may have influenced the risk of developing metabolic syndrome for those currently without the syndrome. This was consistent with the results of the ecological analysis presented in Table 4, and in Figure 1. We observed the prevalence of metabolic syndrome in workplaces in 2011 was associated with the prevalence of the syndrome with past asymptomatic workers in 2015. We should recognize workplaces as potential areas in which we can intervene in order to prevent metabolic syndrome from developing.

Many studies have suggested that social support exerts a significant effect on behavior change and disease prevention.[28] Social support includes informational, tangible, and emotional support.[28] Such support is provided not only by the spouse and the

Table 5. Adjusted hazard ratios for metabolic syndrome development stratified according to sex ($n = 136{,}985$).[a]

		Hazard ratio (95% CI)	
		Male ($n = 104{,}420$)	Female ($n = 32{,}565$)
Age (years) (2011)	40–49	1.00	1.00
	50–59	1.05 (1.02–1.08)	1.19 (1.09–1.29)
	60–74	1.06 (0.95–1.17)	1.01 (0.75–1.37)
Waist (2011)	Male: <85 cm, female: <90 cm	1.00	1.00
	Male: ≥85 cm, female: ≥90 cm	3.77 (3.62–3.93)	1.51 (1.34–1.70)
BMI(kg/m^2) (2011)	<25	1.00	1.00
	≥25	1.64 (1.57–1.71)	7.63 (6.85–8.50)
Blood pressure (2011)	SBP: <130 mmHg and DBP: <85 mmHg	1.00	1.00
	SBP: ≥130 mmHg or DBP: ≥85 mmHg,	1.35 (1.30–1.39)	1.72 (1.55–1.92)
Fasting glucose (2011)	<100 mg/dL	1.00	1.00
	≥100 mg/dL	1.27 (1.23–1.32)	1.60 (1.42–1.79)
HbA1c (2011)	<5.6	1.00	1.00
	≥5.6	1.08 (1.02–1.15)	1.08 (0.89–1.31)
Triglycerides (2011)	<150 mg/dL	1.00	1.00
	≥150 mg/dL	1.47 (1.42–1.52)	1.77 (1.51–2.06)
HDL (2011)	≥40 mg/dL	1.00	1.00
	<40 mg/dL	1.47 (1.38–1.57)	1.80 (1.25–2.61)
Smoking (2011)	No	1.00	1.00
	Yes	1.05 (1.02–1.07)	1.03 (0.94–1.13)
Alcohol consumption (2011)	No/Sometimes	1.00	1.00
	Every day	1.02 (0.99–1.04)	0.82 (0.74–0.92)
Regular exercise (2011)[b]	Yes	1.00	1.00
	No	0.97 (0.94–1.00)	1.00 (0.89–1.13)
Physical activity (2011)[c]	Yes	1.00	1.00
	No	0.99 (0.96–1.01)	0.98 (0.90–1.07)
Walking speed (2011)[d]	Fast	1.00	1.00
	Average/Slow	1.00 (0.97–1.02)	0.90 (0.83–0.97)
≥10 kg weight gain from the age of 20 (2011)	No	1.00	1.00
	Yes	1.98 (1.93–2.04)	3.26 (2.98–3.56)
≥ ±3 kg weight change within a year (2011)	No	1.00	1.00
	Yes	1.22 (1.18–1.26)	1.40 (1.29–1.51)
Eating speed (2011)[e]	Average/Slow	1.00	1.00
	Fast	1.22 (1.19–1.26)	1.30 (1.20–1.40)
Eat a meal within 2 h before bedtime (2011)	<3 days/week	1.00	1.00
	≥3 days/week	0.93 (0.91–0.96)	0.90 (0.83–0.98)
Have a late-night snack (2011)	<3 days/week	1.00	1.00
	≥3 days/week	0.81 (0.78–0.84)	0.70 (0.64–0.77)
Skip breakfast (2011)	<3 days/week	1.00	1.00
	≥3 days/week	0.94 (0.91–0.96)	0.81 (0.74–0.89)
Sleep sufficiency (2011)[f]	Sufficient	1.00	1.00
	Insufficient	0.96 (0.93–0.99)	0.89 (0.83–0.96)
Business category (2011)	Manufacturing	1.00	1.00
	Nonmanufacturing	0.89 (0.85–0.92)	1.21 (1.11–1.33)
Prevalence group (2011)	Low-prevalence group (<29.9%)	1.00	1.00
	High-prevalence group (≥29.9%)	1.10 (1.07–1.14)	1.09 (1.00–1.18)

Note. BMI = body mass index; CI = confidence interval; DBP = diastolic blood pressure; HbA1c = glycated hemoglobin; HDL = high-density lipoprotein; na = not available; SBP = systolic blood pressure.

[a]The analysis was performed after excluding participants with missing data.

[b]In Japan's "specific health checkup system", *regular exercise* is defined as having exercised enough to break a light sweat for at least 30 minutes a day, twice a week, for at least a year.

[c]In Japan's "specific health checkup system", *physical activity* is defined as at least 1 hour a day of walking or comparable physical activities.

[d]In Japan's "specific health checkup system", *walking speed* is relative speed compared with the walking speed of others of comparable age and of the same sex, as judged by respondents subjectively.

[e]In Japan's "specific health checkup system", *eating speed* is the relative speed compared with the eating speed of others, as judged by respondents subjectively.

[f]In Japan's "specific health checkup system", *sleeping efficacy or having "sufficient" sleep* is defined as having enough rest from sleeping.

family but also by colleagues at the workplace. A large retrospective cohort study conducted in the U.S has shown that social relationship, though not always recognized by the individual, has an influence on the likelihood of developing obesity.[29] The current study evaluated whether the workplace is a potential factor effecting the development of the metabolic syndrome. The result indicates that social relationships in the workplace have an independent effect on the risk for metabolic syndrome. Therefore, we may infer that the workplace itself is a factor that should be improved to promote health. This supports the idea that a population-based approach to the prevention of metabolic syndrome that includes not only interventions to ensure the good health of asymptomatic people but also those aimed at improving working conditions is required.

Previous studies have shown that workplace-related factors play an important role in the development of metabolic syndrome among employees.[11–24,30–33] Although we could not perform further analysis due to lack of access to detailed information on workplace-related factors characteristic of business categories, these factors may have been associated with the increased risk for metabolic syndrome in the high-prevalence group in the current study.

Workplace-related factors can be reduced to the "type of work", such as night shift work, and "working conditions", such as having discretion over one's work and stress level. Longitudinal studies have shown that the type of work, including night shift work and sedentary desk work, has an effect on the risk of metabolic syndrome.[15] Several studies have found a significant relationship between sitting time or physical activity during work and metabolic syndrome incidence.[22,23,30] Moreover, some studies have reported that the increased risk of metabolic syndrome applied only to men but not to women.[15,22] It is expected that a certain proportion of shift workers or desk workers were included in this study population. Thus, the type of work could have impacted the differences in the risk for metabolic syndrome between the high and low-prevalence groups in the current study.

In addition to the type of work, work conditions appeared to be associated with a higher risk of metabolic syndrome. It has been suggested that job-related psychological stress and the amount of control one has over one's work may be factors in the work environment that have longitudinal effects on metabolic syndrome incidence. A national survey of labor in Japan revealed that 55.7% people had high levels of perceived job strains, and that the main causes of job strains were 'quantity and quality of work', 'interpersonal relationships', and 'failure and responsibility at work'.[34] These job strains may have impacted the differences in risk of developing metabolic syndrome in the current study.

We can infer, then, that the type of work, and work conditions are affected by the business category that a person works in. Our results showed that men possessed a smaller risk, whilst women had a larger risk, for metabolic syndrome occurring at nonmanufacturing companies than those at manufacturing companies. Even though we could not gain detailed information about their working conditions within this study, we present two possible reasons for the difference in risks for the two genders. One reason could be men and women hold different job positions within the same industries in Japan. Another reason is that men and woman are affected differently by other people, and by their environments. This is an interesting point, and more research on the mechanisms of gender differences and disease development in workplaces is needed.

The present study has several limitations. As described above, due to the limited data used for the analysis, this study was unable to take into accounts detailed factors pertaining to workplaces with a high prevalence of metabolic syndrome. To identify workplaces in which employees are prone to developing the metabolic syndrome, future analyses will need to take a more comprehensive and detailed look at data pertaining to employees' working conditions (eg, actual working hours, whether there is shift work, whether employees have discretion over their work, and how stressful the work is) in addition to focusing on business categories. We analyzed the data after excluding participants with missing data on covariates. Therefore, our result may have been affected by information bias due to missing values. Due to unavailability of data, we were also unable to examine whether socio-economic status had an effect on an insured member's susceptibility to developing the metabolic syndrome. However, given that the sample consisted of data on employees working in major companies, it is fair to assume that the average socio-economic status was relatively high. Further studies should include the potential effects of socio-economic status based on data such as employee compensation and academic background. Moreover, insurance society and workplace programs, and other initiatives to improve employee health may have had an effect on metabolic syndrome incidence, but this point also remains to be studied. Since 2017, all company-sponsored insurance societies are obligated to report to the Japanese government on implementation of the health promotion and maintenance projects. Through the utilization of these data, future studies may be able to evaluate the effects of these project implementations on the risk of metabolic syndrome.

Conclusion

In this study's large sample, the risk of metabolic syndrome among men was higher in high-prevalence groups than in the low-prevalence groups. This result suggests that in workplaces with a high prevalence of metabolic syndrome, health education and other interventions are needed for asymptomatic employees. At the same time, changes to existing working conditions need to be considered to prevent further incidences. Further study is required to identify workplace-related factors associated with the risk for metabolic syndrome.

Data availability statement

Data subject to third party restrictions. The data that support the findings of this study are available from *Hokenjakinou wo suishinshrukai* (http://www.kino-suishin.org/). Restrictions apply to the availability of these data, which were used under license for this study. Data are available from the authors with the permission of *Hokenjakinou wo suishinshrukai*.

Disclosure statement

No potential conflict of interest was reported by the authors.

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References

1. Ministry of Health, Labour, and Welfare. Specific Health Checkups and Specific Health Guidance. Ministry of Health, Labour, and Welfare Web site. http://www.mhlw.go.jp/english/wp/wp-hw3/dl/2-007.pdf. Published April 12, 2013. Accessed April 26, 2018.
2. Ministry of Health, Labour and Welfare. The National Health and Nutrition Survey in Japan, Published November 14, 2015. 2015. [in Japanese].
3. Davila EP, Florez H, Fleming LE, et al. Prevalence of the metabolic syndrome among U.S. workers. *Diabetes Care*. 2010;33(11):2390–2395. doi:10.2337/dc10-0681.
4. Hidaka T, Hayakawa T, Kakamu T, et al. Prevalence of metabolic syndrome and its components among Japanese workers by clustered business category. *PLoS One*. 2016;11(4):e0153368. doi:10.1371/journal. pone.0153368.
5. Leischik R, Foshag P, Strauß M, et al. Physical activity, cardiorespiratory fitness and carotid intima thickness: sedentary occupation as risk factor for atherosclerosis and obesity. *Eur Rev Med Pharmacol Sci*. 2015;19(17):3157–3168.
6. Leischik R, Foshag P, Strauß M, et al. Aerobic capacity, physical activity and metabolic risk factors in firefighters compared with police officers and sedentary clerks. *PLoS One*. 2015;10(7):e0133113. doi:10.1371/journal.pone.0133113.
7. Strauß M, Foshag P, Przybylek B, et al. Occupation and metabolic syndrome: is there correlation? A cross sectional study in different work activity occupations of German firefighters and office workers. *Diabetol Metab Syndr*. 2016;8(1):57. doi:10.1186/s13098-016-0174-0.
8. Lee W, Yeom H, Yoon JH, et al. Metabolic outcomes of workers according to the International Standard Classification of Occupations in Korea. *Am J Ind Med*. 2016;59(8):685–694. doi:10.1002/ajim.22596.
9. Nam JY, Kim J, Cho KH, et al. Associations of sitting time and occupation with metabolic syndrome in South Korean adults: a cross-sectional study. *BMC Public Health*. 2016;16:943. doi:10.1186/s12889-016-3617-5.
10. Sanchez-Chaparro MA, Calvo-Bonacho E, Gonzalez-Quintela A, et al. Occupation-related differences in the prevalence of metabolic syndrome. *Diabetes Care*. 2008;31(9):1884–1885. doi:10.2337/dc08-0431.
11. Mohebbi I, Shateri K, Seyedmohammadzad M. The relationship between working schedule patterns and the markers of the metabolic syndrome: comparison of shift workers with day workers. *Int J Occup Med Environ Health*. 2012;25(4):383–391. doi:10.2478/S13382-012-0051-5.
12. Wang F, Zhang L, Zhang Y, et al. Meta-analysis on night shift work and risk of metabolic syndrome. *Obes Rev*. 2014;15(9):709–720. doi:10.1111/obr.12194.
13. Kawada T, Otsuka T. Effect of shift work on the development of metabolic syndrome after 3 years in Japanese male workers. *Arch Environ Occup Health*. 2014;69(1):55–61. doi:10.1080/19338244.2012.732123.
14. Bekkers MB, Koppes LL, Rodenburg W, van Steeg H, Proper KI. Relationship of night and shift work with weight change and lifestyle behaviors. *J Occup Environ Med*. 2015;57(4):e37–e44. doi:10.1097/JOM.0000000000000426.
15. Lin YC, Hsieh IC, Chen PC. Utilizing the metabolic syndrome component count in workers' health surveillance: An example of day-time vs. day-night rotating shift workers. *Int J Occup Med Environ Health*. 2015;28(4):675–688. doi:10.13075/ijomeh.1896.00335.
16. Guo Y, Rong Y, Huang X, et al. Shift work and the relationship with metabolic syndrome in Chinese aged workers. *PLoS One*. 2015;10(3):e0120632. doi:10.1371/journal.pone.0120632.
17. Yu KH, Yi YH, Kim YJ, et al. Shift work is associated with metabolic syndrome in young female Korean workers. *Korean J Fam Med*. 2017;38(2):51–56. doi:10.4082/kjfm.2017.38.2.51.
18. Li Y, Sato Y, Yamaguchi N. Shift work and the risk of metabolic syndrome: a nested case-control study. *Int J Occup Environ Health*. 2011;17(2):154–160. doi:10.1179/107735211799030960.
19. Staiano AE, Harrington DM, Barreira TV, Katzmarzyk PT. Sitting time and cardiometabolic risk in US adults: associations by sex, race, socioeconomic status and activity level. *Br J Sports Med*. 2014;48(3):213–219. doi:10.1136/bjsports-2012-091896.
20. Petersen CB, Nielsen AJ, Bauman A, Tolstrup JS. Joint association of physical activity in leisure and total sitting time with metabolic syndrome amongst 15,235 Danish adults: a cross-sectional study. *Prev Med*. 2014;69:5–7. doi:10.1016/j.ypmed.2014.08.022.

21. Moreno-Franco B, Penalvo JL, Andres-Esteban EM, et al. Association between daily sitting time and prevalent metabolic syndrome in an adult working population: The AWHS cohort. *Nutr Hosp*. 2015; 32(6):2692–2700. doi:10.3305/nh.2015.32.6.9806.
22. Lin TC, Courtney TK, Lombardi DA, Verma SK. Association between sedentary work and BMI in a U.S. national longitudinal survey. *Am J Prev Med*. 2015;49(6):e117–e123. doi:10.1016/j.amepre.2015. 07. 024.
23. Zhou Z, Xi Y, Zhang F, et al. Sedentary behavior predicts changes in cardiometabolic risk in professional workers: A one-year prospective study. *J Occup Environ Med*. 2016;58(4):e117–e123. doi:10.1097/JOM.0000000000000673.
24. Engelen L, Gale J, Chau JY, et al. Who is at risk of chronic disease? Associations between risk profiles of physical activity, sitting and cardio-metabolic disease in Australian adults. *Aust N Z J Public Health*. 2017; 41(2):178–183. doi:10.1111/1753-6405.12627.
25. National Federation of Health Insurance Societies (Kenporen): Specific health check-up and specific health guidance uptake statistics for 2011, June, 2013. [in Japanese]
26. Matsuzawa Y. Metabolic syndrome-definition and diagnostic criteria in Japan. *Jpn Soc Int Med*. 2005;94: 188–203. [in Japanese]
27. Kohro T, Furui Y, Mitsutake N, et al. The Japanese national health screening and intervention program aimed at preventing worsening of the metabolic syndrome. *Int Heart J*. 2008;49(2):193–203.
28. Holt-Lunstad J, Uchino BN. Social suport and health. In: Glanz K, Rimer BK, Viswanath K, eds. *Health Behavior*. 5th ed. San Francisco, USA: Jossey-Bass; 2015:183–204.
29. Christakis N, Fowler JH. The spread of obesity in a large social network over 32 years. *N Engl J Med*. 2007;357(4):370–379. doi:10.1056/NEJMsa066082.
30. Kuwahara K, Honda T, Nakagawa T, et al. Leisure-time exercise, physical activity during work and commuting, and risk of metabolic syndrome. *Endocrine*. 2016;53(3):710–721. doi:10.1007/s12020-016-0911-z.
31. Hwang WJ, Lee CY. Effect of psychosocial factors on metabolic syndrome in male and female blue-collar workers. *Jpn J Nurs Sci*. 2014;11(1):23–34. doi: 10.1111/j.1742-7924.2012.00226.
32. Edwards EM, Stuver SO, Heeren TC, Fredman L. Job strain and incident metabolic syndrome over 5 years of follow-up: the coronary artery risk development in young adults study. *J Occup Environ Med*. 2012;54(12): 1447–1452. doi:10.1097/JOM.0b013e3182783f27.
33. Pedersen JM, Lund R, Andersen I, Clark AJ, Prescott E, Rod NH. Psychosocial risk factors for the metabolic syndrome: A prospective cohort study. *Int J Cardiol*. 2016;215:41–46. doi:10.1016/j.ijcard.2016. 04.076.
34. Ministry of Health, Labour and Welfare: Occupational Health and Safety Survey 2015, 2017. [in Japanese]