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Changes in the psychosocial work characteristics and insulin resistance among Japanese male workers: a three-year follow-up study

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Abstract: Objective: This study investigated the impact of changes in psychosocial work characteristics on insulin resistance (IR) among Japanese male workers. **Methods:** Subjects were 1,815 male workers who received a comprehensive health examination and requested measurement of their serum insulin level in Fiscal Years (FY) 2008 and 2011. Psychosocial work characteristics, including job demands, job control, and workplace social support (from supervisors and coworkers), were assessed in each of the job demands-control and demand-control-support models. Psychosocial work characteristics were assessed by the Brief Job Stress Questionnaire. Changes in the psychosocial work characteristics were measured by creating a four-category variable for each of the psychosocial work characteristics: (1) stable low group, (2) increased group, (3) decreased group, and (4) stable high group. We defined IR as a value of 2.5 or more on the homeostasis model assessment of insulin resistance (HOMA-IR), or having a diagnosis of diabetes. A series of multiple logistic regression analyses were conducted. **Results:** The group experiencing a decrease in supervisor support had a significantly higher risk of having IR compared to the stable high group with an odds ratio (OR) of 2.44; 95% CI: 1.48-4.02. After adjusting for covariates, this significant association was unchanged; the OR was 2.19; 95% CI: 1.23-3.91. On the other hand, there was no significant association of changes in the psychosocial work characteristics, expect for decrease in supervisor support, with IR. **Conclusions:** A decrease in supervisor support was found to be an independent risk factor for worsening IR.
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Key words: Homeostasis model assessment of insulin resistance (HOMA-IR), Japan, Job demands-control (JDC) model, Longitudinal studies, Psychosocial work characteristics, Type 2 diabetes

Introduction

The number of people with Type 2 diabetes is growing rapidly worldwide. According to the International Diabetes Federation (IDF) report[1,2], 387 million (8.3%) adults have been diagnosed with diabetes (including Type 1 and Type 2 diabetes) worldwide. Furthermore, the number of people with diabetes will exceed 592 million within 25 years. The Western Pacific Region, including Japan, has the largest number (138 million) of diabetic adults, and the number of diabetic adults in this region is expected to increase to 218 million by 2035. In Japan, 7.2 million people have diabetes and Japan has the 10th highest prevalence rate of diabetes in the world. Diabetes imposes a large economic burden on individuals and their families, on national health systems, and on countries. Health spending on diabetes accounted for 11% of total health expenditures worldwide in 2014[2]. Global health spending to treat diabetes and manage complications totaled at least USD 612 billion in 2014[2]. Notably, half of all adults with diabetes are between the ages of 40 and 59 years and almost all diabetic adults in this age group suffer from Type 2 diabetes[3]. This middle-aged group, who are in the

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prime of life, will continue to comprise the greatest number of people with diabetes in the coming years. Therefore, the prevention of diabetes among middle-aged people is important in the workplace.

Preceding studies have investigated the risk factors for Type 2 diabetes, including obesity[4], physical inactivity[5,6], smoking[7], heavy alcohol use[8], and inadequate duration of sleep[9]. In addition, psychosocial stress resulting from specific psychosocial characteristics in occupational settings has also been hypothesized to increase the risk of Type 2 diabetes[10]. To explain the effects of psychosocial work characteristics on Type 2 diabetes, two kinds of underlying mechanisms are hypothesized. The first mechanism known as a "direct effect", suggests that psychosocial stress has been linked to increasing serum glucose levels and poor glucose tolerance among diabetic patients[11]. The second mechanism known as an "indirect effect," suggests that psychosocial stress has been linked to well-established Type 2 diabetes risk factors, such as obesity[12], metabolic syndrome[13], smoking, alcohol consumption, and physical inactivity[14].

Studies investigating the impact of psychosocial work characteristics on Type 2 diabetes or glucose tolerance, have been conducted using either the job demands-control (JD-C) model or the demand-control-support (DCS) model, which includes measures of job demands, job control, supervisor support, and coworker support[15,16]. These studies have been conducted both in domestic and overseas settings, however, their findings have been inconsistent and inconclusive[10]. For example, a cross-sectional study of Japanese male workers showed a significant association of job strain (i.e., the combination of high job demands and low job control) and workplace social support with hemoglobin A_{1c} (HbA_{1c})[17]. On the contrary, another study of Japanese male workers failed to show a significant association of psychosocial work characteristics with Type 2 diabetes assessed by an oral glucose tolerance test[18]. In foreign countries (i.e., other than Japan), two longitudinal studies showed a significant association of high job strain with self-reported or doctor diagnosed Type 2 diabetes[19,20]. Two other longitudinal studies showed a significant association of high job strain with Type 2 diabetes assessed by an oral glucose tolerance test among women[21,22]. Furthermore, two cross-sectional studies showed a significant association of high job strain and low job control with Type 2 diabetes among women[23,24]. However, other three longitudinal and cross-sectional studies failed to show a significant association of psychosocial work characteristics with Type 2 diabetes among men and women[25-27].

In addition to this inconclusive evidence for the association of psychosocial work characteristics with Type 2 diabetes or glucose tolerance, all of the longitudinal studies introduced above only assessed the psychosocial work characteristics at a single point in time (i.e., baseline) even though these characteristics may change over time. Therefore, when we focus on the psychosocial work characteristics associated with Type 2 diabetes or glucose tolerance, "time-dependent change" of these characteristics should be taken into account.

Furthermore, early diagnosis and treatment of Type 2 diabetes are the most important ways to prevent its progression and its associated complications. Insulin resistance (IR) occurs prior to the onset of Type 2 diabetes; therefore, improving IR may delay or prevent the onset and/or progression of Type 2 diabetes and identifying the psychosocial work characteristics associated with IR is of great importance for workers. In order to quantify IR, the gold standard is the glucose clamp technique. However, this technique is procedurally complicated and is difficult to complete[28]. Alternatively, a homeostasis model assessment of insulin resistance (HOMA-IR) has been introduced as one of the most convenient indices to determine IR level. HOMA-IR has a strong correlation with the results of the glucose clamp technique[29]. HOMA-IR has been used as a measure of IR to determine the association of IR with the onset of coronary heart disease[30] as well as to determine the association between IR and circulating adipocytokines such as plasma resistin or leptin[31]. To the best of our knowledge, however, the association of psychosocial work characteristics with IR measured by HOMA-IR has not been fully investigated.

The purpose of this study was to investigate the impact of changes in the psychosocial work characteristics on IR. Changes in psychosocial work characteristics were measured using the JD-C and DCS models over three years. We hypothesized that; (1) workers who experienced a favorable change in psychosocial work characteristics would decrease their risk of elevating their level of IR, and (2) workers who experienced an unfavorable change in psychosocial work characteristics would increase their risk of elevating their level of IR.

Methods

Participants

Participant data was collected from annual comprehensive health examinations conducted on workers in a health care center in the Kanto (east coast) region of Japan in fiscal years (FY) 2008 and 2011. A comprehensive health examination has been conducted on workers for 35 years or more in this health care center, and at the time of examination, the examinees could request a check on their serum insulin level. The data were collected on serum analysis of IR, a physical examination, and a self-administered questionnaire, which included scales on job demands, job control, and social support in the workplace.

Due to the small sample size of female workers, we used the health examination data of male workers only,

which included the serum insulin level measured in FY 2008 and 2011. At baseline (FY 2008), 29,586 male workers underwent a comprehensive health examination, and of these, a total of 6,128 workers requested to measure the serum insulin level. Of 6,128 workers, 1,359 workers were excluded from the study for the following reasons: past history of diabetes, fasting plasma glucose (FPG) level ≥126 mg/dL and HbA_{1c} ≥6.5 %, as indicated by the National Glycohemoglobin Standardization Program (NGSP) units (diagnostic criteria for diabetes)[32], or an IR value ≥2.5, as measured by HOMA-IR. Moreover, we excluded 520 shift workers, who are reported to have a higher risk of diabetes[33]. After further excluding 877 workers who had one or more missing questionnaire responses, 3,372 workers were eligible for a follow-up survey. Of 3,372 workers, 1,816 workers requested to measure the serum insulin levels at the time of the follow-up survey, in FY 2011. Furthermore, we excluded one worker who had FPG levels of 140 mg/dL or more, because the association of FPG with IR is weakened when the FPG is 140 mg/dL or more[32]. Therefore, the number of study participants was 1,815. Compared to the final sample (n=1,815), the dropout sample (n=1,557) had significantly higher prevalence of current smokers, lower alcohol consumption, lower BMI, higher HbA_{1c}, and lower job demands. Demographic and occupational characteristics and lifestyle behaviors of participants are shown in Table 1. Glucose metabolism and psychosocial work characteristics of participants are shown in Table 2.

The study protocol was approved by the Ethics Committee of the Hitachi, Limited Ibaraki Hospital Group (Ibaraki, Japan) in 2008 and 2011. Written informed consent was obtained from all participants.

Measures

1) Psychosocial work characteristics

Based on the JD-C or DCS model[15,16], psychosocial work characteristics included job demands, job control, and workplace social support (i.e., supervisor support and coworker support). We assessed psychosocial work characteristics using the Brief Job Stress Questionnaire (BJSQ)[34]. The BJSQ includes four three-item scales: (1) the job demands scale (Cronbach's α coefficient was 0.67 and 0.72 at baseline and follow-up, respectively), (2) the job control scale (Cronbach's α coefficient was 0.78 and 0.77 at baseline and follow-up, respectively), (3) the supervisor support scale (Cronbach's α coefficient was 0.84 and 0.85 at baseline and follow-up, respectively), and (4) the coworker support scale (Cronbach's α coefficient was 0.79 and 0.82 at baseline and follow-up, respectively), each with a response range of 3-12. We also calculated the job demands/control ratio (range 0.25-4.00) to quantify the degree of job strain[35]. High exposure to job control and workplace social support, and low exposure to job demands and job strain were considered beneficial. The participants were dichotomized into high and low groups relative to the median of each scale score or job demands/control ratio at baseline and follow-up, respectively.

According to a preceding study[36], changes in psychosocial work characteristics were measured by creating a four-category variable for each psychosocial work characteristic: (1) stable low group (low group at both baseline and follow-up), (2) increased group (low group at baseline with high group at follow-up), (3) decreased group (high group at baseline with low group at follow-up), and (4) stable high group (high group at both baseline and follow-up). We defined the decreased group as a favorable change group in terms of job demands and job strain, whereas we defined the increased group as a favorable change group in terms of job control, supervisor support, and coworker support. Detailed demographic and occupational characteristics and lifestyle behaviors of participants at baseline, according to changes in psychosocial work characteristics, are shown in Appendices A-E.

2) Glucose metabolism

All participants were assessed for FPG, HbA_{1c}, and immuno-reactive insulin (IRI) levels. We calculated HOMA-IR using the HOMA model (HOMA-IR = FPG [mg/dL] * IRI [μU/mL] / 405)[29]. Participants were dichotomized using the recommended cut-off value of HOMA-IR for the Japanese population[32] into those with IR (≥2.5 on HOMA-IR) and those without IR (<2.5 on HOMA-IR).

The quality of each biochemical test was assessed by internal and external quality control methods. For the internal quality control method, we first calculate the mean (M), standard deviation (SD), and coefficient variation (CV) for the control sample. Subsequently, we measured the control sample daily before measuring the specimen sample to check the difference between M, SD, and CV scores of the specimen sample and the control score set in advance. FPG was measured using the electrode method (GA082, A&T Corporation, Kanagawa, Japan) and the reagent was calibrated once per day. HbA_{1c} was measured by high performance liquid chromatography (HPLC) method (G9, Tosoh Corporation, Tokyo, Japan) and the reagent was calibrated once per week. IRI was measured by the chemiluminescence immunoassay (CLIA) method (i1000SR, Abbott Japan, Co., Ltd, Tokyo, Japan) and the reagent was calibrated once a month. For the external quality control method, we measured M, SD and CV in control samples sent from quality control organizations (e.g., Japan Medical Association, Tokyo, Japan) and reported the results to the organizations. Subsequently, we received feedback from the organizations on the M, SD, and CV scores.

3) Other covariates

Other covariates included demographic characteristics (i.e., age and marital status), occupational characteristics

Table 1. Demographic and occupational characteristics and lifestyle behaviors of participants

	Total (*n*=1,815)	
	Mean (SD)	*n* (%)
Baseline (FY 2008)		
Age	50.16 (7.58)	
35-39 years old		215 (11.8)
40-49 years old		538 (29.6)
50-59 years old		942 (51.9)
60 years old or more		120 (6.6)
Marital status		
Currently married		1581 (87.1)
Never married		187 (10.3)
Divorced/widowed		47 (2.6)
Department		
Design engineering department		538 (29.6)
Inspection department		197 (10.9)
Production assembling department		346 (19.1)
Production control department		144 (7.9)
Transportation department		17 (0.9)
General affairs department		279 (15.4)
Sales department		51 (2.8)
Data input department		4 (0.2)
Research department		85 (4.7)
Medical department		4 (0.2)
Service department		13 (0.7)
Others		137 (7.5)
Employment position and occupation		
Manager		767 (42.3)
Main career track		552 (30.4)
General clerk		107 (5.9)
Non-clerical workers		360 (19.8)
Others		29 (1.6)
Smoking history		
Non smoker		1146 (63.1)
Current smoker		669 (36.9)
Alcohol consumption [g/wk]	126.48 (121.52)	
0-44		663 (36.5)
45-154		554 (30.5)
155 or more		598 (32.9)
Exercise habits		
Yes		738 (40.7)
No		1077 (59.3)
Sleeping hours		
<5 hours		104 (5.7)
≥5 hours to <6 hours		808 (44.5)
≥6 hours to <7 hours		740 (40.8)
≥7 hours		163 (9.0)
Body mass index [kg/m^2]	23.67 (2.54)	
Low (22.5 or less)		601 (33.7)
Middle (22.6-24.6)		615 (33.9)
High (24.7 or more)		589 (32.5)

Table 1. Demographic and occupational characteristics and lifestyle behaviors of participants (continued)

	Total (*n*=1,815)	
	Mean (SD)	*n* (%)
Follow-up (FY 2011)		
Smoking history		
Non smoker		1295 (71.3)
Current smoker		520 (28.7)
Alcohol consumption [g/wk]	125.70 (123.33)	
0-44		581 (32.0)
45-154		652 (35.9)
155 or more		582 (32.1)
Exercise habits		
Yes		744 (41.0)
No		1071 (59.0)
Sleeping hours		
<5 hours		107 (5.9)
≥5 hours to <6 hours		788 (43.4)
≥6 hours to <7 hours		725 (39.9)
≥7 hours		195 (10.7)

(i.e., department and employment position and occupation), psychosocial work characteristics (i.e., job demands, job control, supervisor support, and coworker support), lifestyle behaviors (i.e., smoking history, alcohol consumption, exercise habits, and sleeping hours), and body mass index (BMI) at baseline, and changes in lifestyle behaviors during the follow-up period. Except for the BMI, these covariates were assessed using a self-administered questionnaire.

Age was classified into four groups: 35-39 years old, 40-49 years old, 50-59 years old, and 60 years old or older. Marital status was classified into three groups: currently married, never married, and divorced or widowed. Department was classified into 12 groups using the original classification in the questionnaire (see Table 1). Employment position and occupation was classified into five groups: manager, main career track, general clerk, non-clerical workers, and others. Psychosocial work characteristics at baseline, such as scores of job demands, job control, supervisor support, and coworker support, were used as continuous variables. Smoking history was classified into two groups: non smoker and current smoker. Alcohol consumption was classified into three groups using the tertile: 44 g/wk or less, 45-154 g/wk, and 155 g/wk or more. Exercise habits were classified into two groups: yes or no. Sleeping hours were classified into four groups: <5 hours, ≥5 hours to <6 hours, ≥6 hours to <7 hours, and ≥7 hours. BMI was classified into three groups using the tertile: 22.5 kg/m^2 or less, 22.6-24.6 kg/m^2, and 24.7 kg/m^2 or more. Changes in lifestyle behaviors were classified into three or four categories using data from each lifestyle behavior at baseline and follow-up. Changes in smoking history were classified into four groups: continuing smoker, continuing non-smoker, quitter, and initiator or relapsed quitter. Changes in alcohol consumption were classified into three groups: no change, increased, and decreased. Changes in exercise habits were classified into four groups: continual exercising, never exercised, stopped exercising, and commenced exercise. Changes in sleeping hours were classified into three groups: no change, increased, and decreased.

Statistical analysis

According to a preceding study[36], using the stable low group or stable high group as a reference, a series of multiple logistic regression analyses were conducted to estimate the ORs and 95% confidence intervals (CIs) of IR (defined as having a diagnosis of diabetes, meeting the diabetes diagnostic criteria described earlier, or having a value of 2.5 or more on HOMA-IR at follow-up) for increased or decreased group of each psychosocial work characteristic. In the analyses, we first calculated the crude ORs (i.e., without any adjustment) (Model 1). We then adjusted for demographic characteristics (i.e., age and marital status) (Model 2), and subsequently for occupational characteristics (i.e., department and employment position and occupation) (Model 3), for psychosocial work characteristics at baseline (i.e., scores of job demands, job control, supervisor support, and coworker support) (Model 4), for lifestyle behaviors at baseline (i.e., sleeping hours, smoking history, alcohol consumption, and exercise habits) (Model 5), for BMI (Model 6), and

Table 2. Glucose metabolism and psychosocial work characteristics of participants (n=1,815)

Glucose metabolism	Baseline		Follow-up	
	Mean (SD)		Mean (SD)	
Fasting plasma glucose (FPG) [mg/dl]	99.66 (7.99)		105.27 (9.31)	
Hemoglobin A_{1c} (HbA_{1c}) [%]	5.26 (0.28)		5.20 (0.37)	
Immuno-reactive insulin (IRI) [μU/ml]	5.00 (2.10)		5.40 (2.40)	
Homeostasis model assessment-insulin resistance (HOMA-IR)	1.24 (0.54)		1.42 (0.68)	
Scale scores (BJSQ)†	Mean (SD)	Cronbach's α	Mean (SD)	Cronbach's α
Job demands	8.39 (1.82)	0.67	7.98 (1.94)	0.72
Job control	9.00 (1.93)	0.78	9.20 (1.86)	0.77
Job strain (job demands/control ratio)	1.00 (0.42)	–	0.93 (0.41)	–
Supervisor support	7.43 (1.87)	0.83	7.38 (1.87)	0.85
Coworker support	7.86 (1.67)	0.79	7.83 (1.73)	0.82

† BJSQ, Brief Job Stress Questionnaire.

Table 3. Prevalence of insulin resistance at follow-up by changes in psychosocial work characteristics†

	n	No. of case (%)
Job demands		
Stable low	735	56 (7.6)
Increased	165	6 (3.6)
Decreased	337	32 (9.5)
Stable high	578	42 (7.3)
Job control		
Stable low	971	81 (8.3)
Increased	250	12 (4.8)
Decreased	183	10 (5.5)
Stable high	411	33 (8.0)
Job strain (job demands/control)		
Stable low	715	58 (8.1)
Increased	169	8 (4.7)
Decreased	307	26 (8.5)
Stable high	624	44 (7.1)
Supervisor support		
Stable low	749	57 (7.6)
Increased	220	11 (5.0)
Decreased	250	33 (13.2)
Stable high	596	35 (5.9)
Coworker support		
Stable low	889	67 (7.5)
Increased	223	15 (6.7)
Decreased	216	21 (9.7)
Stable high	487	33 (6.8)

† Insulin resistance was defined as a value of 2.5 or more on the HOMA-IR at follow-up.

finally for changes in lifestyle behaviors (Model 7). The level of significance was 0.05 (two-tailed). Statistical analyses were performed using IBM SPSS Statistics version 22.

Results

The mean score of HOMA-IR was 1.24 (SD=0.54) at baseline and 1.42 (SD=0.68) at follow-up, respectively (Table 2). The prevalence of workers with IR at follow-up was 7.5% (n=136). Of 136 workers with IR, 111 workers had a value of 2.5 or more on HOMA-IR, nine workers had a diagnosis of diabetes, two workers met the diabetes diagnostic criteria, and 14 workers met these requirements redundantly. The prevalence of IR at follow-up by changes in psychosocial work characteristics is shown in Table 3.

For supervisor support, the multiple logistic regression analyses revealed that the decreased group had a significantly higher OR for IR compared to the stable high group (Model 1) (OR=2.44; 95% CI: 1.48-4.02) (Table 4). This pattern was unchanged after adjusting for demographic characteristics (Model 2), occupational characteristics (Model 3), psychosocial work characteristics at baseline (Model 4), and lifestyle behaviors at baseline (Model 5). After also adjusting for BMI and changes in lifestyle behaviors, the association was attenuated but still statistically significant (Models 6 and 7).

For job control, the increased group had a marginally significantly lower OR for IR compared to the stable low group (OR=0.55; 95% CI: 0.30-1.03). After adjusting for covariates (Models 2-7), however, this association was no longer marginally significant.

There was no significant association of change in job demands, job strain (job demands/control), or coworker support with IR before or after adjusting for any covariates.

Table 4. Association of changes in psychosocial work characteristics with insulin resistance: logistic regression analysis†

	Odds ratio (95% confidence interval)			
	Model 1‡	Model 2§	Model 3 ‖	Model 4¶
Job demands				
Increased [a]	0.46 (0.19-1.08)	0.45 (0.19-1.07)	0.45 (0.19-1.09)	0.47 (0.19-1.14)
Decreased [b]	1.34 (0.83-2.17)	1.29 (0.79-2.12)	1.28 (0.77-2.13)	1.26 (0.75-2.13)
Job control				
Increased [a]	0.55 (0.30-1.03)	0.59 (0.32-1.11)	0.59 (0.31-1.12)	0.55 (0.29-1.06)
Decreased [b]	0.66 (0.32-1.37)	0.75 (0.36-1.58)	0.79 (0.37-1.68)	0.76 (0.35-1.65)
Job strain (job demands/control)				
Increased [a]	0.56 (0.26-1.20)	0.56 (0.25-1.21)	0.56 (0.25-1.22)	0.56 (0.25-1.25)
Decreased [b]	1.22 (0.74-2.02)	1.33 (0.79-2.24)	1.25 (0.73-2.15)	1.29 (0.74-2.27)
Supervisor support				
Increased [a]	0.64 (0.33-1.24)	0.65 (0.33-1.28)	0.65 (0.33-1.28)	0.66 (0.33-1.31)
Decreased [b]	2.44 (1.48-4.02)	2.45 (1.48-4.06)	2.35 (1.40-4.00)	2.59 (1.50-4.46)
Coworker support				
Increased [a]	0.89 (0.50-1.58)	0.85 (0.48-1.53)	0.86 (0.48-1.56)	0.84 (0.46-1.54)
Decreased [b]	1.48 (0.84-2.63)	1.45 (0.81-2.59)	1.53 (0.84-2.80)	1.54 (0.83-2.88)

	Odds ratio (95% confidence interval)		
	Model 5**	Model 6††	Model 7‡‡
Job demands			
Increased [a]	0.44 (0.18-1.08)	0.46 (0.19-1.15)	0.49 (0.20-1.24)
Decreased [b]	1.22 (0.72-2.06)	1.16 (0.68-1.99)	1.13 (0.65-1.97)
Job control			
Increased [a]	0.55 (0.28-1.06)	0.58 (0.30-1.13)	0.67 (0.34-1.33)
Decreased [b]	0.79 (0.36-1.73)	0.75 (0.34-1.68)	0.78 (0.34-1.79)
Job strain (job demands/control)			
Increased [a]	0.52 (0.23-1.18)	0.57 (0.25-1.28)	0.57 (0.25-1.31)
Decreased [b]	1.23 (0.70-2.17)	1.22 (0.68-2.17)	1.24 (0.68-2.29)
Supervisor support			
Increased [a]	0.66 (0.33-1.32)	0.68 (0.34-1.38)	0.66 (0.32-1.37)
Decreased [b]	2.40 (1.37-4.19)	2.18 (1.24-3.86)	2.19 (1.23-3.91)
Coworker support			
Increased [a]	0.86 (0.47-1.59)	0.90 (0.48-1.67)	0.93 (0.49-1.75)
Decreased [b]	1.54 (0.82-2.91)	1.76 (0.92-3.39)	1.78 (0.90-3.49)

† Insulin resistance was defined as having a score of 2.5 or more on HOMA-IR at follow-up.
‡ Crude (i.e., without any adjustment).
§ Adjusted for demographic characteristics (i.e., age and marital status).
‖ Additionally adjusted for occupational characteristics (i.e., job department, employment position and occupation).
¶ Additionally adjusted for psychosocial work characteristics at baseline.
** Additionally adjusted for lifestyle behaviors (i.e., sleeping hours, smoking history, alcohol consumption, and exse habits) at baseline.
†† Additionally adjusted for body mass index.
‡‡ Additionally adjusted for changes in lifestyle behaviors.
[a] Comparison group is stable low group.
[b] Comparison group is stable high group.

Discussion

In this study, we found a significant association between decreasing supervisor support and IR. This significant association was unchanged after adjusting for any covariates. There was no significant association observed between changes in the other psychosocial work characteristics and IR.

In the present study, the group that experienced a decrease in supervisor support had a significantly higher OR for IR compared to the group in which supervisor support remained stable and high. This finding is consistent with a preceding cross-sectional study of Japanese male workers, which showed a negative and significant association of workplace social support with HbA_{1c}[17]. The present study replicated this evidence using a longitudinal design especially in the situation where unfavorable change in supervisor support occurs.

As we introduced earlier, the mechanism of the effect of psychosocial stress on Type 2 diabetes has been hypothesized to have one of two effects, and these include a "direct effect" or an "indirect effect"[11-14]. We investigated these effects by adjusting for lifestyle behavior at baseline and for BMI, as well as for changes in lifestyle behaviors as covariates, in a series of multiple logistic regression analyses. As a result, the significant association of decreasing supervisor support with IR was observed even after adjusting for lifestyle behaviors at baseline (Model 5) (OR=2.40; 95% CI: 1.37-4.19), BMI (Model 6) (OR= 2.18; 95% CI: 1.24-3.86), and changes in lifestyle behaviors (Model 7) (OR=2.19; 95% CI: 1.23-3.91) while the association was slightly attenuated compared to Model 4 (OR=2.59; 95% CI: 1.50-4.46). Similar trends were observed in a preceding study on UK civil servants[21]. These findings suggest that the association of decreasing supervisor support with increasing IR is partially mediated by BMI and lifestyle behaviors as well as by their time dependent changes, and that such a mediation (or indirect) effect is minimal.

In contrast, we found no significant association of increasing supervisor support with IR. This finding may be explained by a traditional two-factor theory, sometimes known as Herzberg's motivation-hygiene theory[37]. In this theory, hygiene factors, including the workers relationship with a supervisor, does not provide positive satisfaction, though dissatisfaction results from their absence. For that reason, a decrease in supervisor support would affect IR, but an increase in supervisor support would not necessarily prevent IR. Furthermore, we did not find a significant association of changes in coworker support with IR. The vertical principle in Japanese society may explain this finding[38]. In the Japanese workplace, vertical relationships remains deeply rooted while horizontal relationships are relatively weak compared to those in other countries, therefore, changes in supervisor support rather than changes in coworker support, may have a greater impact on IR.

There was no significant association between changes in job demands, job control, or job strain and IR. Since we surveyed middle-aged male workers who received a comprehensive health examination and had their level of serum insulin checked, they may have had enough time and money to have an "optional" health examination and had higher levels of health awareness. In fact, the present sample had lower levels of job demands and job strain and higher levels of job control, compared to those who received only mandatory annual health examination in the same health care center (data not shown), which may lead to non-significant association of a change in job demands, job control, or job strain with IR.

Our study has several strengths. First, this is the first longitudinal study based on the JD-C or DCS models, which investigates the association of changes in psychosocial work characteristics with IR. Most preceding longitudinal studies measured the psychosocial work characteristics only once, which would not assess whether psychosocial work characteristics had changed. Second, we demonstrated the association of psychosocial work characteristics with IR measured by HOMA-IR as an objective variable. Almost all the preceding studies showed the association of psychosocial work characteristics with Type 2 diabetes. We focused on the earlier and reversible level of worsening glucose metabolism using HOMA-IR. High supervisor support may prevent worsening IR in occupational settings.

Some possible limitations to this study must be considered. First, as mentioned earlier, we surveyed only male workers who received a comprehensive health examination and requested to have their serum insulin level checked. In a future study, we need to reduce the potential for selection bias by measuring the serum insulin level at random among all of the people (men and women) who completed an annual health examination. Second, the present sample came from one big manufacturing company group in Japan. Therefore, generalization of the findings should be done with caution. Third, although we excluded those who had been diagnosed with diabetes at baseline from the study, past history of other kinds of diseases could not be considered or adjusted, which may mask the true association because those who had suffered from some kind of disease might have experienced higher levels of job resources (especially supervisor support). Future research should consider the effects of various medical history and/or workplace consideration on the present findings. Fourth, while we adjusted for exercise habits during leisure time, this was assessed by a single item questionnaire with a dichotomous option. Furthermore, the level of physical activity during working hours could not be adjusted; however, it might be possi-

ble to partially adjust for this variable by including occupational characteristics in the statistical model. In the future, we would measure the occupational and leisure time metabolic equivalents (METs) to assess physical activity levels more precisely. Fifth, we could not discriminate Type 1 diabetes and Type 2 diabetes clearly. In the present study, we surveyed middle-aged male workers, excluding those who had been diagnosed with diabetes at baseline to reduce the influence of juvenile-onset Type 1 diabetes as possible. Finally, due to investigational circumstances (i.e., difficulties with following up subjects over a longer period of time), we investigated the association of changes in psychosocial work characteristics with IR over a three-year period only. Earlier longitudinal studies on the association of psychosocial work characteristics with Type 2 diabetes used a 6-15 year follow-up period[19-21,27]. However, since our outcome variable was IR, which is a preliminary stage of Type 2 diabetes, the three-year follow-up period (i.e., shorter than six years) is reasonable and valid. However, further studies are needed to confirm a more appropriate duration of follow-up periods for assessing the effects of changes in psychosocial work characteristics on IR.

Conclusions

To the best of our knowledge, this is the first study to assess the association of changes in psychosocial work characteristics with IR. The present study showed that a decrease in supervisor support was an independent risk factor of worsening IR. Furthermore, high supervisor support may reduce the risk of Type 2 diabetes in the future. Further research should reveal the psychological and biological mechanisms underlying the association of a change in supervisor support over time with IR.

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Appendix A. Demographic and occupational characteristics and lifestyle behaviors of participants at baseline by change in job demands

Change in job demands	Stable low (*n*=735)		Increased (*n*=165)		Decreased (*n*=337)		Stable high (*n*=578)		*p*
	Mean (SD)	*n* (%)	Mean (SD)	*n* (%)	Mean (SD)	*n* (%)	Mean (SD)	*n* (%)	
Age	52.11 (7.42)		47.91 (7.28)		51.60 (7.28)		47.47 (7.27)		<0.001/<0.001[a]
35-39 years old		57 (7.8)		30 (18.2)		23 (6.8)		105 (18.2)	
40-49 years old		176 (23.9)		53 (32.1)		95 (28.2)		214 (37.0)	
50-59 years old		416 (55.6)		80 (48.5)		199 (59.1)		247 (42.7)	
60 years old or more		86 (11.7)		2 (1.2)		20 (2.1)		12 (2.1)	
Marital status									0.094
Currently married		634 (86.3)		141 (85.5)		300 (89.0)		506 (87.5)	
Never married		72 (9.8)		21 (12.7)		31 (9.2)		63 (10.9)	
Divorced/widowed		29 (3.9)		3 (1.8)		6 (1.8)		9 (1.6)	
Department									0.003
Design engineering department		175 (23.8)		56 (33.9)		103 (30.6)		204 (35.3)	
Inspection department		79 (10.7)		16 (9.7)		44 (13.1)		58 (10.0)	
Production assembling department		149 (20.3)		35 (21.2)		60 (17.8)		102 (17.6)	
Production control department		58 (7.9)		8 (4.8)		31 (9.2)		47 (8.1)	
Transportation department		11 (1.5)		1 (0.6)		3 (0.9)		2 (0.3)	
General affairs department		127 (17.3)		33 (20.0)		46 (13.6)		73 (12.6)	
Sales department		31 (4.2)		1 (0.6)		7 (2.1)		12 (2.1)	
Data input department		1 (0.1)		0 (0)		2 (0.6)		1 (0.2)	
Research department		35 (4.8)		5 (3.0)		12 (3.6)		33 (5.7)	
Medical department		0 (0)		0 (0)		1 (0.3)		3 (0.5)	
Service department		6 (0.8)		1 (0.6)		4 (1.2)		2 (0.3)	
Others		63 (8.6)		9 (5.5)		24 (7.1)		41 (7.1)	
Employment position and occupation									<0.001
Manager		286 (38.9)		59 (35.8)		164 (48.7)		258 (44.6)	
Main career track		186 (15.3)		68 (41.2)		94 (27.9)		204 (35.3)	
General clerk		60 (8.2)		5 (3.0)		19 (5.6)		23 (4.0)	
Non-clerical workers		179 (24.4)		32 (19.4)		58 (17.2)		91 (15.7)	
Others		24 (3.3)		1 (0.6)		2 (0.3)		2 (0.3)	
Smoking history									0.763
Non smoker		464 (63.1)		105 (63.6)		205 (60.8)		372 (64.4)	
Current smoker		271 (36.9)		60 (36.4)		132 (39.2)		206 (35.6)	

Appendix A. Demographic and occupational characteristics and lifestyle behaviors of participants at baseline by change in job demands (continued)

Change in job demands	Stable low (*n*=735)		Increased (*n*=165)		Decreased (*n*=337)		Stable high (*n*=578)		*p*
	Mean (SD)	*n* (%)	Mean (SD)	*n* (%)	Mean (SD)	*n* (%)	Mean (SD)	*n* (%)	
Alcohol consumption [g/wk]	133.42 (124.57)		127.56 (130.44)		129.98 (119.86)		115.32 (115.28)		0.056/0.110[a]
0-44		258 (35.1)		64 (38.8)		116 (34.4)		225 (38.9)	
45-154		210 (28.6)		49 (29.7)		106 (31.5)		189 (32.7)	
155 or more		267 (36.3)		52 (31.5)		115 (34.1)		164 (28.4)	
Exercise habits									0.035
Yes		324 (44.1)		71 (43.0)		133 (39.5)		210 (36.3)	
No		411 (55.9)		94 (57.0)		204 (60.5)		368 (63.7)	
Sleeping hours									<0.001
<5 hours		21 (2.9)		8 (4.8)		24 (7.1)		51 (8.8)	
≥5 hours to <6 hours		268 (36.5)		77 (46.7)		161 (47.8)		302 (52.2)	
≥6 hours to <7 hours		351 (47.8)		64 (38.8)		126 (37.4)		199 (34.4)	
≥7 hours		95 (12.9)		16 (9.7)		26 (7.7)		26 (4.5)	
Body mass index [kg/m^2]	23.58 (2.53)		23.44 (2.61)		23.79 (2.56)		23.79 (2.50)		0.239/0.573[a]
Low (22.5 or less)		254 (34.6)		66 (40.0)		105 (31.2)		186 (32.2)	
Middle (22.6-24.6)		247 (33.6)		50 (30.3)		118 (35.0)		200 (34.6)	
High (24.7 or more)		234 (31.8)		49 (29.7)		114 (33.8)		192 (33.2)	

[a] *p* values for continuous variables are shown in left side; *p* values for categorical variables are shown in right side

Appendix B. Demographic and occupational characteristics and lifestyle behaviors of participants at baseline by change in job control

Change in job control	Stable low (*n*=971)		Increased (*n*=250)		Decreased (*n*=183)		Stable high (*n*=411)		*p*
	Mean (SD)	*n* (%)	Mean (SD)	*n* (%)	Mean (SD)	*n* (%)	Mean (SD)	*n* (%)	
Age	48.72 (7.33)		50.82 (7.77)		49.84 (8.14)		53.29 (6.81)		<0.001/<0.001[a]
35-39 years old		139 (14.3)		28 (11.2)		28 (15.3)		20 (4.9)	
40-49 years old		340 (35.0)		69 (27.6)		48 (26.2)		81 (19.7)	
50-59 years old		457 (47.1)		132 (52.8)		94 (51.4)		259 (63.0)	
60 years old or more		35 (3.6)		21 (8.4)		13 (7.1)		51 (12.4)	
Marital status									<0.001
Currently married		807 (83.1)		222 (88.8)		165 (90.2)		387 (94.2)	
Never married		141 (14.5)		20 (8.0)		14 (7.7)		14 (7.7)	
Divorced/widowed		23 (2.4)		8 (3.2)		4 (2.2)		4 (2.2)	
Department									0.001
Design engineering department		313 (32.2)		65 (26.0)		56 (30.6)		104 (25.3)	
Inspection department		117 (12.0)		27 (10.8)		10 (5.5)		43 (10.5)	
Production assembling department		193 (19.9)		43 (17.2)		31 (16.9)		79 (19.2)	
Production control department		75 (7.7)		22 (8.8)		13 (7.1)		34 (8.3)	
Transportation department		7 (0.7)		7 (2.8)		1 (0.5)		2 (0.5)	
General affairs department		128 (13.2)		46 (18.4)		27 (14.8)		78 (19.0)	
Sales department		24 (2.5)		10 (4.0)		10 (5.5)		7 (1.7)	
Data input department		3 (0.3)		0 (0)		0 (0)		1 (0.2)	
Research department		42 (4.3)		9 (3.6)		14 (7.7)		20 (4.9)	
Medical department		1 (0.1)		0 (0)		0 (0)		3 (0.7)	
Service department		9 (0.9)		1 (0.4)		0 (0)		3 (0.7)	
Others		59 (6.1)		20 (8.0)		21 (11.5)		37 (9.0)	
Employment position and occupation									<0.001
Manager		364 (37.5)		114 (45.6)		86 (47.0)		203 (49.4)	
Main career track		339 (34.9)		73 (29.2)		55 (30.1)		85 (20.7)	
General clerk		58 (6.0)		6 (2.4)		12 (6.6)		31 (7.5)	
Non-clerical workers		201 (20.7)		53 (21.2)		27 (14.8)		79 (19.2)	
Others		9 (0.9)		4 (1.6)		3 (1.6)		13 (3.2)	
Smoking history									0.078
Non smoker		592 (61.0)		157 (62.8)		116 (63.4)		281 (68.4)	
Current smoker		379 (39.0)		93 (37.2)		67 (36.6)		130 (31.6)	

Appendix B. Demographic and occupational characteristics and lifestyle behaviors of participants at baseline by change in job control (continued)

Change in job control	Stable low (*n*=971)		Increased (*n*=250)		Decreased (*n*=183)		Stable high (*n*=411)		*p*
	Mean (SD)	*n* (%)	Mean (SD)	*n* (%)	Mean (SD)	*n* (%)	Mean (SD)	*n* (%)	
Alcohol consumption [g/wk]	123.20 (124.31)		130.06 (122.83)		133.07 (124.10)		129.12 (112.78)		0.647/0.091[a]
0-44		382 (39.3)		90 (36.0)		58 (31.7)		133 (32.4)	
45-154		282 (29.0)		73 (29.2)		68 (37.2)		131 (31.9)	
155 or more		307 (31.6)		87 (34.8)		57 (31.1)		147 (35.8)	
Exercise habits									<0.001
Yes		324 (33.4)		117 (46.8)		95 (51.9)		202 (49.1)	
No		647 (66.6)		133 (53.2)		88 (48.1)		209 (50.9)	
Sleeping hours									<0.001
<5 hours		104 (5.7)		16 (6.4)		8 (4.4)		12 (2.9)	
≥5 hours to <6 hours		808 (44.5)		112 (44.8)		79 (43.2)		137 (33.3)	
≥6 hours to <7 hours		740 (40.8)		103 (41.2)		82 (44.8)		193 (47.0)	
≥7 hours		163 (9.0)		19 (7.6)		14 (7.7)		69 (16.8)	
Body mass index [kg/m^2]	23.66 (2.66)		23.42 (2.20)		23.80 (2.40)		23.81 (2.46)		0.250/0.068[a]
Low (22.5 or less)		344 (35.4)		90 (36.0)		54 (29.5)		123 (29.9)	
Middle (22.6-24.6)		305 (31.4)		93 (37.2)		72 (39.3)		145 (35.3)	
High (24.7 or more)		322 (33.2)		67 (26.8)		57 (31.1)		143 (34.8)	

[a] *p* values for continuous variables are shown in left side; *p* values for categorical variables are shown in right side

Appendix C. Demographic and occupational characteristics and lifestyle behaviors of participants at baseline by change in job strain

Change in job strain (job demands/control)	Stable low (*n*=715)		Increased (*n*=169)		Decreased (*n*=307)		Stable high (*n*=624)		*p*
	Mean (SD)	*n* (%)	Mean (SD)	*n* (%)	Mean (SD)	*n* (%)	Mean (SD)	*n* (%)	
Age	52.74 (7.16)		48.05 (7.05)		51.17 (7.23)		47.27 (7.21)		<0.001/<0.001[a]
35-39 years old		47 (6.6)		26 (15.4)		26 (8.5)		116 (18.8)	
40-49 years old		151 (21.1)		62 (36.7)		84 (27.4)		241 (28.6)	
50-59 years old		433 (60.6)		78 (46.2)		175 (57.0)		256 (41.0)	
60 years old or more		84 (11.7)		3 (1.8)		22 (7.2)		11 (1.8)	
Marital status									<0.001
Currently married		637 (89.1)		145 (85.8)		274 (89.3)		525 (84.1)	
Never married		50 (7.0)		21 (12.4)		27 (8.8)		89 (14.3)	
Divorced/widowed		28 (3.9)		3 (1.8)		6 (2.0)		10 (1.6)	
Department									0.031
Design engineering department		177 (24.8)		57 (33.7)		91 (29.6)		213 (34.1)	
Inspection department		73 (10.2)		22 (13.0)		41 (13.4)		61 (9.8)	
Production assembling department		137 (19.2)		28 (16.6)		58 (18.9)		123 (19.7)	
Production control department		57 (8.0)		11 (6.5)		20 (6.5)		56 (9.0)	
Transportation department		9 (1.3)		2 (1.2)		4 (1.3)		2 (0.3)	
General affairs department		136 (19.0)		24 (14.2)		40 (13.0)		79 (12.7)	
Sales department		26 (3.6)		3 (1.8)		11 (3.6)		11 (1.8)	
Data input department		1 (0.1)		0 (0)		2 (0.7)		1 (0.2)	
Research department		34 (4.8)		6 (3.6)		9 (2.9)		36 (5.8)	
Medical department		1 (0.1)		0 (2)		1 (0.3)		2 (0.3)	
Service department		5 (0.7)		1 (0.6)		3 (1.0)		4 (0.6)	
Others		59 (8.3)		15 (8.9)		27 (8.8)		36 (5.8)	
Employment position and occupation									<0.001
Manager		314 (43.9)		69 (40.8)		146 (47.6)		238 (38.1)	
Main career track		174 (24.3)		58 (34.3)		83 (27.0)		237 (38.0)	
General clerk		52 (7.3)		7 (4.1)		18 (5.9)		30 (4.8)	
Non-clerical workers		152 (21.3)		34 (20.1)		57 (18.6)		117 (18.8)	
Others		23 (3.2)		1 (0.6)		3 (1.6)		2 (0.3)	
Smoking history									0.050
Non smoker		461 (64.5)		113 (66.9)		173 (56.4)		399 (63.9)	
Current smoker		254 (35.5)		56 (33.1)		134 (43.6)		225 (36.1)	

Appendix C. Demographic and occupational characteristics and lifestyle behaviors of participants at baseline by change in job strain (continued)

Change in job strain (job demands/control)	Stable low (*n*=715)		Increased (*n*=169)		Decreased (*n*=307)		Stable high (*n*=624)		*p*
	Mean (SD)	*n* (%)	Mean (SD)	*n* (%)	Mean (SD)	*n* (%)	Mean (SD)	*n* (%)	
Alcohol consumption [g/wk]	139.14 (123.16)		125.13 (123.08)		119.93 (122.44)		115.57 (117.64)		0.003/0.004[a]
0-44		232 (32.4)		60 (35.5)		120 (39.1)		251 (40.2)	
45-154		207 (29.0)		59 (34.9)		96 (31.3)		192 (30.8)	
155 or more		276 (38.6)		50 (29.6)		91 (29.6)		181 (29.0)	
Exercise habits									<0.001
Yes		332 (46.4)		81 (47.9)		114 (37.1)		211 (33.8)	
No		383 (53.6)		88 (52.1)		193 (62.9)		413 (66.2)	
Sleeping hours									<0.001
<5 hours		17 (2.4)		7 (4.1)		20 (6.5)		60 (9.6)	
≥5 hours to <6 hours		247 (34.5)		79 (46.7)		151 (49.2)		331 (53.0)	
≥6 hours to <7 hours		348 (48.7)		68 (40.2)		116 (37.8)		208 (33.3)	
≥7 hours		103 (14.4)		15 (8.9)		20 (6.5)		25 (4.0)	
Body mass index [kg/m^2]	23.70 (2.56)		23.68 (2.49)		23.58 (2.67)		23.69 (2.58)		0.925/0.817[a]
Low (22.5 or less)		229 (32.0)		57 (33.7)		111 (36.2)		214 (34.3)	
Middle (22.6-24.6)		249 (34.8)		62 (36.7)		100 (32.6)		204 (32.7)	
High (24.7 or more)		237 (33.1)		50 (29.6)		96 (31.3)		206 (33.0)	

[a] *p* values for continuous variables are shown in left side; *p* values for categorical variables are shown in right side

Appendix D. Demographic and occupational characteristics and lifestyle behaviors of participants at baseline by change in supervisor support

Change in supervisor support	Stable low (*n*=749)		Increased (*n*=220)		Decreased (*n*=250)		Stable high (*n*=596)		*p*
	Mean (SD)	*n* (%)	Mean (SD)	*n* (%)	Mean (SD)	*n* (%)	Mean (SD)	*n* (%)	
Age	50.19 (7.23)		49.83 (7.43)		48.92 (7.65)		50.75 (7.99)		<0.001/0.025[a]
35-39 years old		80 (10.7)		29 (13.2)		37 (14.8)		69 (11.6)	
40-49 years old		227 (30.3)		66 (30.0)		87 (34.8)		158 (26.5)	
50-59 years old		403 (53.8)		114 (51.8)		108 (43.2)		317 (53.2)	
60 years old or more		39 (5.2)		11 (5.0)		18 (7.2)		52 (8.7)	
Marital status									0.006
Currently married		630 (84.1)		192 (87.3)		216 (86.4)		543 (91.1)	
Never married		95 (12.7)		26 (11.8)		26 (10.4)		40 (6.7)	
Divorced/widowed		24 (3.2)		2 (0.9)		8 (3.2)		13 (2.2)	
Department									0.194
Design engineering department		224 (29.9)		59 (26.8)		86 (34.4)		169 (28.4)	
Inspection department		92 (12.3)		23 (10.5)		26 (10.4)		56 (9.4)	
Production assembling department		151 (20.2)		41 (18.6)		38 (15.2)		116 (19.5)	
Production control department		65 (8.7)		20 (9.1)		13 (5.2)		46 (7.7)	
Transportation department		7 (0.9)		1 (0.5)		4 (1.6)		5 (0.8)	
General affairs department		100 (13.4)		38 (17.3)		40 (16.0)		101 (16.9)	
Sales department		15 (2.0)		7 (3.2)		11 (4.4)		18 (3.0)	
Data input department		0 (0)		0 (0)		2 (0.8)		2 (0.3)	
Research department		33 (4.4)		9 (4.1)		7 (2.8)		36 (6.0)	
Medical department		2 (0.3)		0 (0)		0 (0)		2 (0.3)	
Service department		4 (0.5)		2 (0.9)		0 (0)		7 (1.2)	
Others		56 (7.5)		20 (9.1)		23 (9.2)		38 (6.4)	
Employment position and occupation									<0.001
Manager		273 (36.4)		81 (36.8)		128 (51.2)		285 (47.8)	
Main career track		241 (32.2)		71 (32.3)		73 (29.2)		167 (28.0)	
General clerk		53 (7.1)		11 (5.0)		12 (4.8)		31 (5.2)	
Non-clerical workers		175 (23.4)		53 (24.1)		34 (13.6)		98 (16.4)	
Others		7 (0.9)		4 (1.8)		3 (1.2)		15 (2.5)	
Smoking history									0.187
Non smoker		459 (61.3)		131 (59.5)		163 (65.2)		393 (65.9)	
Current smoker		290 (38.7)		89 (40.5)		87 (34.8)		203 (34.1)	

Appendix D. Demographic and occupational characteristics and lifestyle behaviors of participants at baseline by change in supervisor support (continued)

Change in supervisor support	Stable low (*n*=749)		Increased (*n*=220)		Decreased (*n*=250)		Stable high (*n*=596)		*p*
	Mean (SD)	*n* (%)	Mean (SD)	*n* (%)	Mean (SD)	*n* (%)	Mean (SD)	*n* (%)	
Alcohol consumption [g/wk]	120.24 (124.44)		126.54 (118.51)		121.08 (125.44)		136.58 (116.77)		0.086/0.002[a]
0-44		305 (40.7)		81 (36.8)		102 (40.8)		175 (29.4)	
45-154		217 (29.0)		65 (29.5)		73 (29.2)		199 (33.4)	
155 or more		227 (30.3)		74 (33.6)		75 (30.0)		222 (37.2)	
Exercise habits									0.036
Yes		275 (36.7)		92 (41.8)		109 (44.0)		262 (44.0)	
No		474 (63.3)		128 (58.2)		141 (56.4)		334 (56.0)	
Sleeping hours									0.001
<5 hours		53 (7.1)		8 (3.6)		22 (8.8)		21 (3.5)	
≥5 hours to <6 hours		345 (46.1)		91 (41.4)		116 (46.4)		256 (43.0)	
≥6 hours to <7 hours		300 (40.1)		103 (46.8)		91 (36.4)		246 (41.3)	
≥7 hours		51 (6.8)		18 (8.2)		21 (8.4)		73 (12.2)	
Body mass index [kg/m^2]	23.60 (2.59)		23.29 (2.46)		24.23 (2.62)		23.68 (2.42)		<0.001/0.005[a]
Low (22.5 or less)		271 (36.2)		85 (38.6)		67 (26.8)		188 (31.5)	
Middle (22.6-24.6)		249 (33.2)		76 (34.5)		78 (31.2)		212 (35.6)	
High (24.7 or more)		229 (30.6)		59 (26.8)		105 (42.0)		196 (32.9)	

[a] *p* values for continuous variables are shown in left side; *p* values for categorical variables are shown in right side

Appendix E. Demographic and occupational characteristics and lifestyle behaviors of participants at baseline by change in coworker support

Change in coworker support	Stable low (*n*=889)		Increased (*n*=223)		Decreased (*n*=216)		Stable high (*n*=487)		*p*
	Mean (SD)	*n* (%)	Mean (SD)	*n* (%)	Mean (SD)	*n* (%)	Mean (SD)	*n* (%)	
Age	50.27 (7.39)		50.30 (6.97)		49.40 (7.65)		50.22 (8.15)		0.488/0.005[a]
35-39 years old		102 (11.5)		15 (6.7)		28 (13.0)		70 (14.4)	
40-49 years old		256 (28.8)		83 (37.2)		78 (36.1)		121 (24.8)	
50-59 years old		477 (53.7)		110 (49.3)		95 (44.0)		260 (53.4)	
60 years old or more		54 (6.1)		15 (6.7)		15 (6.9)		36 (7.4)	
Marital status									0.011
Currently married		750 (84.4)		194 (87.0)		192 (88.9)		445 (91.4)	
Never married		110 (12.4)		26 (11.7)		18 (8.3)		33 (6.8)	
Divorced/widowed		29 (3.3)		3 (1.3)		6 (2.8)		9 (1.8)	
Department									0.003
Design engineering department		271 (30.5)		71 (31.8)		58 (26.9)		138 (28.3)	
Inspection department		117 (13.2)		21 (9.4)		16 (7.4)		43 (8.8)	
Production assembling department		166 (18.7)		46 (20.6)		36 (16.7)		98 (20.1)	
Production control department		76 (8.5)		20 (9.0)		19 (8.8)		29 (6.0)	
Transportation department		12 (1.3)		3 (1.3)		0 (0)		2 (0.4)	
General affairs department		125 (14.1)		30 (13.5)		36 (16.7)		88 (18.1)	
Sales department		17 (1.9)		3 (1.3)		14 (6.5)		17 (3.5)	
Data input department		1 (0.1)		0 (0)		2 (0.9)		1 (0.2)	
Research department		39 (4.4)		9 (4.0)		11 (5.1)		26 (5.3)	
Medical department		0 (0)		0 (0)		1 (0.5)		3 (0.5)	
Service department		3 (0.3)		1 (0.4)		3 (1.4)		6 (1.2)	
Others		62 (7.0)		19 (8.5)		20 (9.3)		36 (7.4)	
Employment position and occupation									0.008
Manager		347 (39.0)		91 (40.8)		102 (47.2)		227 (46.6)	
Main career track		293 (33.0)		60 (26.9)		64 (29.6)		135 (27.7)	
General clerk		56 (6.3)		9 (4.0)		12 (5.6)		30 (6.2)	
Non-clerical workers		186 (20.9)		56 (25.1)		33 (15.3)		85 (17.5)	
Others		7 (0.8)		7 (3.1)		5 (2.3)		10 (2.1)	
Smoking history									0.382
Non smoker		576 (64.8)		131 (58.7)		134 (62.0)		305 (62.6)	
Current smoker		313 (35.2)		92 (41.3)		82 (38.0)		182 (37.4)	

Appendix E. Demographic and occupational characteristics and lifestyle behaviors of participants at baseline by change in coworker support (continued)

Change in coworker support	Stable low (*n*=889)		Increased (*n*=223)		Decreased (*n*=216)		Stable high (*n*=487)		*p*
	Mean (SD)	*n* (%)	Mean (SD)	*n* (%)	Mean (SD)	*n* (%)	Mean (SD)	*n* (%)	
Alcohol consumption [g/wk]	122.02 (120.43)		137.18 (128.02)		128.94 (134.35)		128.65 (114.23)		0.366/0.442[a]
0-44		346 (38.9)		75 (33.6)		81 (37.5)		161 (33.1)	
45-154		262 (29.5)		73 (32.7)		63 (29.2)		156 (32.0)	
155 or more		281 (31.6)		75 (33.6)		72 (33.3)		170 (34.9)	
Exercise habits									0.029
Yes		336 (37.8)		88 (39.5)		90 (41.7)		224 (46.0)	
No		553 (62.2)		135 (60.5)		126 (58.3)		263 (54.0)	
Sleeping hours									0.127
<5 hours		55 (6.2)		6 (2.7)		13 (6.0)		30 (6.2)	
≥5 hours to <6 hours		407 (45.8)		102 (46.8)		101 (46.8)		198 (40.7)	
≥6 hours to <7 hours		356 (40.0)		100 (44.8)		79 (36.6)		205 (42.1)	
≥7 hours		71 (8.0)		15 (6.7)		23 (10.6)		54 (11.1)	
Body mass index [kg/m^2]	23.59 (2.50)		23.34 (2.63)		23.79 (2.54)		23.92 (2.53)		0.019/0.012[a]
Low (22.5 or less)		315 (35.4)		91 (40.8)		69 (31.9)		136 (27.9)	
Middle (22.6-24.6)		301 (33.9)		64 (28.7)		80 (37.0)		170 (34.9)	
High (24.7 or more)		273 (30.7)		68 (30.5)		67 (31.0)		181 (37.2)	

[a] *p* values for continuous variables are shown in left side; *p* values for categorical variables are shown in right side