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Differences in occupational stress by smoking intensity and gender in cross-sectional study of 59 355 Japanese employees using the Brief Job Stress Questionnaire (BJSQ): the Niigata Wellness Study

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ABSTRACT

Objectives It has been hypothesised that smoking intensity may be related to occupational stress. This study aimed to investigate whether stress, including problems with superiors or co-workers, is a driver of smoking.

Design Cross-sectional study.

Setting and participants 59 355 employees (34 865 men and 24 490 women) across multiple occupations who completed a self-reported questionnaire-based occupational stress survey between April 2016 and March 2017 in Niigata Prefecture.

Main outcome measures Stress scores for the Brief Job Stress Questionnaire subscales summed up after assigning high points for high stress and converted to Z-scores based on the mean of all participants. Heavy smokers (HS) smoked ≥15 cigarettes/day and light smokers (LS) smoked <15 cigarettes/day and were compared with non-smokers (NS) by gender.

Results The main subscale items that were significantly associated with smoking status in both genders included 'physical burden', 'irritation' and 'physical symptoms'. In the analysis that included smoking intensity, the stress score for 'co-workers' support' was significantly lower for LS men than NS men (NS 0.091±0.98, LS −0.027±1.00, HS 0.033±0.99), and was significantly higher for HS women than NS women (NS −0.091±1.00, LS −0.080±1.05, HS 0.079±1.03). However, the stress score for 'co-workers' support' was low among LS women aged ≤39 years in the manufacturing industry.

Conclusions It was speculated that LS men and some LS women gained 'co-workers' support' using smoking as a communication tool while reducing the degree of smoking. The existence of such 'social smokers' suggested that to promote smoking cessation, measures are essential to improve the communication between workers in addition to implementing smoking restrictions in the workplace.

Strengths and limitations of this study

- ► The strength of this study is that it is one of the largest comprehensive surveys of more than 50 000 employed individuals in East Asia and describes a wide range of components of occupational stress, including support by superiors or co-workers.
- ► In addition to a simple comparison of smokers and non-smokers, we compared heavy smokers and light smokers separately to clarify stress factors characteristic of women who are heavy smokers and men who are light smokers, which has not been well studied.
- ► We have included industry-specific surveys to clarify conditions of support by co-workers according to smoking rates in workplaces.
- ► A limitation of this study is that it was a cross-sectional study and therefore causal relationships could not be identified.

INTRODUCTION

Smoking is a personal health problem that presents a significant risk for conditions such as malignancies and cardiovascular and respiratory diseases and is a serious public health challenge, such as workplace secondhand smoke and work productivity issues.[1–4] Most studies that include smoking and occupational stress consider both as risk factors for non-communicable diseases and unfavourable habits such as those related to alcohol drinking, overeating and exercise. Only a few studies have focused directly on the relationship between smoking and occupational stress.[5–9] Since the serious health hazards of smoking have become recognised, the smoking rate among Japanese men has

decreased year by year, although it is still high worldwide and the smoking rate among women remains flat.[10 11] Under these circumstances, the revised Health Promotion Law was fully enforced in Japan in 2020. This law stipulates that 'premises of public facilities such as hospitals and schools are non-smoking, commercial and industrial facilities such as offices and restaurants are non-smoking in principle, and in case of violations, a penalty of 500,000 yen or less' will be enforced. However, in existing small-scale restaurants or bars, smoking bans are not enforced, and exceptions are allowed as a transitional measure, which makes this a slightly loose regulation.[12]

Research on the backgrounds of smokers in Japan has been reported in recent years, mainly on educational disparities[13 14] and industry differences.[15] Although there are few academic studies published in English addressing why Japanese workers continue to smoke or why they are unable to quit, in general, many smokers cite 'stress' as a reason.[16 17] Although it was not a study of reasons for smoking, a recent Japanese survey of the general public that included those who were not working reported an association between smoking intensity and 'serious psychological distress' in women.[18] In addition, a market research company (Cross Marketing, Tokyo, Japan)[19] conducted a survey on reasons for smoking and found that 'stress' was cited by 40.4% of smokers as the main reason for smoking in Japan.

There are multiple aspects to occupational stress, and various stress models have been developed to elucidate causal associations with occupational stress. Among them, workload (job demand) and work discretion (job control) are widely accepted as representative causes.[20 21] In addition, workplace relationships are important as a buffer against stress. The demand-control-support (DCS) model, which adds support from co-workers and supervisors to demand and control, is mainly used to investigate the association between cardiovascular disease and work stress in research.[22 23] In recent years, the DCS model and indicators such as workplace social capital or organisational justice have been used to investigate workplace support, but the relationship between smoking and these stress indicators is still controversial.

For example, Kouvonen and colleagues reported that lower 'job control' was associated with increased smoking intensity among civil servant women in Finland while no such association was found in men.[7] In a study of Japanese men in a single workplace, Kawakami and colleagues suggested that the intensity of smoking increased in Japanese men in a group with low job control and low social support.[8] Fukuoka *et al* tracked the outcome of smoking cessation for 2 years and reported no association between stressors and continued smoking cessation in a similar group of male Japanese workers.[24] Studies using other indicators also found that 'low confidence in workplace organizations' was associated with smoking,[9] and 'poor trust relationship with superiors' was associated with smoking in women managers.[5] On the other hand, the opposite result was reported where 'good workplace support' was associated with smoking among women in the nursing profession.[25] Although it has been reported that 'social connections' are involved in both smoking and smoking cessation,[26] other conditions, such as related to workplace environment or duties, might be required for social support to help control smoking.

Because of the very limited number of large-scale comprehensive studies on a variety of industries in the East Asian region, where smoking rates are known to be high, no consistent conclusions can be drawn on the association between various occupational stresses, such as lack of workplace support, and smoking. Therefore, we administered a detailed occupational stress survey, including smoking intensity and workplace support, to approximately 60 000 employees from industries of different sizes and categories to determine the relationship between smoking intensity and occupational stress and differences in the relationship by gender, age and industry.

We hypothesised that smokers experience more occupational stressors than non-smokers (NS), and that the greater the stress, the higher the intensity of smoking. We also hypothesised that better workplace support would buffer stress and suppress smoking. To test these hypotheses, we compared the stress scale of NS, light smokers (LS) and heavy smokers (HS) by gender. Since supportive environments in the workplace vary according to the age of workers and industry, we added comparisons by age group and industry group. Therefore, through our results we could identify measures to promote smoking cessation by reducing working smokers' stress and improving the work environment.

METHODS

Survey participants

Among 64 279 employees who underwent an occupational health examination and stress check based on the Occupational Safety and Health Act between April 2016 and March 2017 in Niigata Prefecture, 34 865 men (mean age 41.8 years old) and 24 490 women (mean age 41.9 years old) participated in this study. Excluded were employees whose gender was unknown, had incomplete examination data, an incomplete stress check response or were ≤19 or ≥70 years old. The industry type was classified according to a large number of persons working at seven occupations and a smaller number of workers in an eighth category designated as 'other'.

Also, in this survey participants were limited to workers at establishments in and around Niigata Prefecture; thus, participants were not representative of workers nationwide.

Patient and public involvement

Patients were not involved in this study.

Stress check

The 57-item 'Brief Job Stress Questionnaire' (BJSQ) developed and validated by Shimomitsu and colleagues

was used to assess occupational stress.[27] It has been used in previous studies as well as in workplaces across the country by the Ministry of Health, Labour and Welfare in guiding the Stress Check Program.[28] The purpose of this programme was to assess stress in individual workers and in the work environment, and its results were reported to be associated with long-term leave and turnover of workers.[29 30] Participants were required to answer questions on the BJSQ using a Likert scale of 1–4 points. The BJSQ contains several related questions, and the scores of the individual questions are added together to produce a result for each category. The total score for each category resulted in high points for high stress (simple total score). Question content was broadly divided into three components: 'Job Stressors', 'Mental and Psychological Stress Reactions ('Stress Reaction')' and 'Social Support'. 'Job Stressors' has nine subscales (job demands, job control, meaningfulness of work, work environment, suitability for work, physical burden, skill utilisation, required job quality, interpersonal relationships), and 'Stress Reaction' has six subscales (vigour, irritation, fatigue, anxiety, depression, physical symptoms). Originally, 'Social Support' included four subscales (superiors, co-workers, family and/or friends (family), life satisfaction), but 'life satisfaction' was excluded because it was not related to support resources. Its elimination left three subscales. Scores were tabulated for each of these three components and 18 subscales.

These simple total scores were compared and examined using Z-score values (Z-scores) standardised from the average score of participants for each component or each subscale. Results with reference to the simple total scores are presented in online supplemental table 1.

Smoking status and intensity

Information on smoking status (smokers or NS) and the number of cigarettes smoked per day was obtained from the medical check-up questionnaire. Based on the median number of cigarettes smoked in the all smokers (AS) group, we defined those who smoked <15 cigarettes/day as LS and those who smoked ≥15 as HS. In the LS, HS and NS groups, the distribution of chronological age was calculated in 10-year increments and the stress check scores (Z-scores) were compared among the three groups.

Analysis of 'Co-workers' support' by industry type and workers' age

To investigate the differences by industry and age, we divided the participants into two age groups (≥40 or ≤39 years old) and compared the 'co-workers' support' subscale by industry categories.

Statistical analysis

Smoking was compared between the AS and NS groups using unpaired t-tests for all 18 subscales, and additionally compared using nominal logistic analysis adjusted for age, body mass index (BMI), amount of alcohol consumption and drinking frequency. Based on the results obtained from the basic statistics, the average age and BMI differed significantly according to smoking intensity. Therefore, age and BMI were selected as items for adjustment. In addition, since a prior publication[31] showed that many workers smoke when drinking, drinking behaviour was also an adjustment item. To clarify the synergy of stress indicators that are strongly related to smoking status, logistic regression analysis was conducted for smoking status to 18 subscales. Three models were tried: model 0 (without adjustment), model 1 (adjusted for age and BMI) and model 2 (model 1 with additional adjustment for amount and frequency of alcohol consumption), and the three subscales with the highest ORs were selected in every trial. Participants with positive or zero Z-scores on the selected subscales were classified as stressed (+) and those with negative Z-scores were classified as stressed (−) to form two groups. Nominal logistic regression analysis was performed on eight combinations of three subscale stresses (+) or (−).

Regarding smoking intensity, the Z-scores of the three components of the BJSQ and the 18 subscales were compared for the NS, LS and HS groups by the Dunnett's test with NS as the control. Z-scores were examined by multivariate analysis adjusted for age and BMI, amount of alcohol consumption and drinking frequency. Additionally, an examination of 'co-workers' support' by industry and age group compared the NS, LS and HS groups by multivariate analyses adjusted for BMI, amount of alcohol consumption and drinking frequency.

JMP for Macintosh (V.14.0.0) was used for statistics.

RESULTS

The smoking rate for the entire study population was 13.6% for women and 41.4% for men. For both genders, the smoking rate by age group was highest in the 40s and the lowest in the 20s. There were more LS and fewer HS among women in all age groups. In men, the number of LS was greatest among those in their 20s. The industry category with the lowest smoking rate was civil servants of both genders (table 1).

Mean age of women smokers was significantly older than for NS; in addition, both LS and HS women were significantly older than NS women. Among men, LS were significantly younger than NS, and HS were significantly older than NS. In women, BMI was significantly lower in LS and higher in HS than in NS, but no significant difference was observed between NS and AS. In men, BMI was significantly lower in AS and LS than in NS, but there was no significant difference in BMI between HS and NS (table 1).

As shown in table 2, many of the stress subscales were independently and significantly associated with smoking. The ORs for each subscale were almost the same in the three models, and even after taking into account the amount and frequency of alcohol consumption, the three highest ORs for both genders were for

Table 1 Demographics of study participants (n=59 355)

Participants	Women					Men				
Smoking status		Non-smokers		Smokers			Non-smokers		Smokers	
Smoking intensity			All smokers	Light smokers	Heavy smokers			All smokers	Light smokers	Heavy smokers
Average (SD)										
Age (years)	41.9 (12.2)	41.7 (12.4)	43.3 (10.6)*	43.0 (10.9)†	44.2 (9.8)†	41.8 (12.5)	41.4 (13.0)	42.3 (11.8)*	38.5 (12.0)†	44.4 (11.2)†
BMI (kg/m^2)	21.76 (3.90)	21.77 (3.88)	21.71 (3.98)	21.55 (3.84)†	22.08 (4.25)†	23.20 (3.73)	23.29 (3.76)	23.08 (3.68)*	22.70 (3.60)†	23.29 (3.71)
Total participants n <smoking rate %>	24 490	21 148	3342 <13.6>	2327 <9.5>	1015 <4.1>	34 865	20 438	14 427 <41.4>	5219 <15.0>	9208 <26.4>
Age group (years)										
20–29	4936	4544	392 <7.9>	313 <6.3>	79 <1.6>	7068	4698	2370 <33.5>	1404 <19.9>	966 <13.7>
30–39	5771	4958	813 <14.1>	575 <10.0>	238 <4.1>	9050	5100	3950 <43.7>	1658 <18.3>	2292 <25.3>
40–49	6293	5150	1143 <18.2>	743 <11.8>	400 <6.4>	8404	4561	3843 <45.7>	1085 <12.9>	2758 <32.8>
50–59	5537	4746	791 <14.3>	558 <10.1>	233 <4.2>	6756	3762	2994 <44.3>	733 <10.8>	2261 <33.5>
60–69	1953	1750	203 <10.4>	138 <7.1>	65 <3.3>	3587	2317	1270 <35.4>	339 <9.5>	931 <25.9>
Industry category										
Service agent	1368	1157	211 <15.4>	145 <10.6>	66 <4.8>	2329	1296	1033 <44.4>	346 <14.9>	687 <29.5>
Medical and welfare	5121	4424	697 <13.6>	511 <10.0>	186 <3.6>	1907	1205	702 <36.8>	365 <19.1>	337 <17.7>
Transportation	774	641	133 <17.2>	85 <11.0>	48 <6.2>	4354	2240	2114 <48.6>	416 <9.6>	1698 <39.0>
Civil servant	3355	3178	177 <5.3>	137 <4.1>	40 <1.2>	2299	1651	648 <28.2>	277 <12.0>	371 <16.1>
Construction industry	366	314	52 <14.2>	34 <9.3>	18 <4.9>	2072	1010	1062 <51.3>	227 <11.0>	835 <40.3>
Retail business	3639	3040	599 <16.5>	405 <11.1>	194 <5.3>	3632	2212	1420 <39.1>	566 <15.6>	854 <23.5>
Manufacturing	8396	7070	1326 <15.8>	906 <10.8>	420 <5.0>	15 689	9183	6506 <41.5>	2674 <17.0>	3832 <24.4>
Other	1471	1324	147 <10.0>	104 <7.0>	43 <2.9>	2583	1641	942 <36.5>	348 <13.5>	594 <23.0>
Alcohol consumption										
Amount (drinks/day)										
≤2.2	18 470	16 481	1989	1419	570	17 064	10 947	6117	2333	3784
2.3–4.4	4511	3614	897	639	258	11 398	6233	5165	1889	3276
4.5–6.6	1212	867	345	209	136	4807	2447	2360	733	1627
≥6.7	297	186	111	60	51	1596	811	785	264	521
Frequency										
Rarely	12 528	11 220	1308	906	402	10 717	6996	3721	1331	2390
Occasionally	8533	7501	1032	760	272	12 042	7446	4596	2062	2534
Every day	3429	2427	1002	661	341	12 106	5996	6110	1826	4284

Continued

Table 1 Continued

Participants	Women				Men			
Smoking status	Non-smokers	Smokers			Non-smokers	Smokers		
Smoking intensity		All smokers	Light smokers	Heavy smokers		All smokers	Light smokers	Heavy smokers

Light smokers <15 cigarettes/day; heavy smokers ≥15 cigarettes/day.
SD is shown in parentheses () in the age and BMI columns, and smoking rate % is shown in the column <> for the total participants, age group, industry category .
*P<0.05 versus non-smokers (unpaired t-test).
†P<0.05 versus non-smokers (Dunnett's test).
BMI, body mass index.

'physical burden', 'irritation' and 'physical symptoms'. Conversely, 'co-workers' support' had the lowest OR of all subscales, especially for men. The risk increased with the combination of the three factors of 'physical burden', 'irritation' and 'physical symptoms' for both genders (table 3).

Compared with NS, the BJSQ simple total score for AS women had significantly higher stress values than for NS in all components (online supplemental table 1). When compared with NS by smoking intensity (figure 1), Z-scores for almost all subscales for HS women were significantly higher, with only 'job demands', 'suitability for work' and 'required job quality' being not significantly different between NS and HS. Results of the multivariate analysis for all 'Social Support' subscales also showed that HS women had significantly higher Z-score values than NS women.

In men, the AS group had slightly but significantly lower scores for 'Social Support' than the NS group (online supplemental table 1). According to smoking intensity, the 'Social Support' score compared with NS was significantly lower in LS by multivariate analysis, but no statistical difference was observed between NS and HS (figure 1). Significantly higher stress scores were shown for 'job demands' and 'required job quality' in LS than in NS.

Since 'co-workers' support' differed from the other subscales in that smokers were less stressed than NS, we added an analysis that included industry type and chronological age (≤39 years old vs ≥40 years old) (figure 2). By industry, in women, HS in the medical and welfare industry had the highest stress scores for 'co-workers' support' compared with NS in the same industry. Exceptionally, LS in the manufacturing industry were characterised by lower stress scores for 'co-workers' support' than NS. In men, LS in the service industry, LS and HS in the manufacturing industry and HS in 'other' industries had significantly lower stress scores for 'co-workers' support' than NS in their respective industries (online supplemental figure 1). By age group, in women, both HS ≥40 years old and HS ≤39 years old had the highest stress scores for 'co-workers' support' compared with NS in their respective age group. In men, HS ≥40 years old, HS ≤39 years old and LS ≤39 years old were characterised by lower stress scores for 'co-workers' support' than NS in their respective age group (online supplemental figure 2). By age group and industry, in women ≤39 years old, HS in the medical and welfare industry had the highest stress scores for 'co-workers' support' compared with NS in the same industry. LS in the manufacturing industry had lower stress scores for 'co-workers' support' than NS in the same industry. In men ≤39 years old, LS in the service industry and LS in the manufacturing industry had significantly lower stress scores for 'co-workers' support' than NS in their respective industries. Also, in men ≥40 years old, HS in the manufacturing industry had significantly lower stress scores for 'co-workers' support' than NS in that industry (figure 2).

Table 2 ORs of smokers to non-smokers for a 1 SD increase in the BJSQ stress Z-score of men and women (by subscales)

	Women, OR (95% CI)			Men, OR (95% CI)		
BJSQ subscales	**Model 0**	**Model 1**	**Model 2**	**Model 0**	**Model 1**	**Model 2**
Job Stressors						
Job demand	0.95 (0.90 to 1.00)	0.96 (0.91 to 1.00)	0.95 (0.90 to 1.00)	0.93 (0.91 to 0.96)	0.95 (0.92 to 0.98)	0.95 (0.92 to 0.97)
Job control	1.00 (0.96 to 1.04)	0.99 (0.95 to 1.03)	0.99 (0.95 to 1.04)	0.95 (0.93 to 0.98)	0.95 (0.93 to 0.97)	0.95 (0.93 to 0.98)
Meaningfulness of work	1.03 (0.98 to 1.08)	1.01 (0.96 to 1.06)	1.02 (0.97 to 1.08)	1.04 (1.00 to 1.07)	1.02 (0.99 to 1.05)	1.02 (0.99 to 1.05)
Work environment	0.98 (0.94 to 1.02)	0.97 (0.93 to 1.01)	0.96 (0.92 to 1.01)	0.99 (0.97 to 1.01)	0.99 (0.96 to 1.01)	0.98 (0.96 to 1.01)
Suitability for work	0.90 (0.86 to 0.95)	0.92 (0.87 to 0.96)	0.90 (0.86 to 0.95)	1.00 (0.97 to 1.03)	1.01 (0.98 to 1.04)	1.01 (0.98 to 1.04)
Physical burden	1.17 (1.12 to 1.21)	1.15 (1.11 to 1.20)	1.17 (1.12 to 1.22)	1.14 (1.11 to 1.17)	1.15 (1.12 to 1.18)	1.15 (1.13 to 1.18)
Skill utilisation	1.04 (1.00 to 1.08)	1.05 (1.01 to 1.09)	1.06 (1.02 to 1.11)	0.97 (0.95 to 1.00)	0.97 (0.95 to 1.00)	0.98 (0.96 to 1.01)
Required job quality	0.95 (0.90 to 1.00)	0.94 (0.90 to 0.99)	0.94 (0.90 to 0.99)	1.02 (0.99 to 1.05)	1.02 (0.99 to 1.05)	1.02 (0.99 to 1.05)
Interpersonal relationship	1.10 (1.05 to 1.15)	1.10 (1.05 to 1.15)	1.09 (1.04 to 1.14)	1.07 (1.04 to 1.10)	1.08 (1.05 to 1.11)	1.07 (1.04 to 1.10)
Stress Reaction						
Vigour	1.01 (0.97 to 1.06)	1.01 (0.97 to 1.06)	1.02 (0.97 to 1.07)	1.03 (1.01 to 1.06)	1.03 (1.00 to 1.06)	1.03 (1.00 to 1.06)
Irritation	1.20 (1.14 to 1.25)	1.22 (1.16 to 1.28)	1.16 (1.11 to 1.22)	1.15 (1.12 to 1.18)	1.16 (1.13 to 1.20)	1.15 (1.11 to 1.18)
Fatigue	1.06 (1.01 to 1.12)	1.08 (1.02 to 1.14)	1.09 (1.03 to 1.16)	1.09 (1.05 to 1.12)	1.11 (1.07 to 1.15)	1.12 (1.08 to 1.16)
Anxiety	0.89 (0.84 to 0.95)	0.89 (0.84 to 0.94)	0.90 (0.85 to 0.95)	0.92 (0.89 to 0.96)	0.92 (0.88 to 0.95)	0.92 (0.89 to 0.95)
Depression	0.94 (0.89 to 1.00)	0.97 (0.91 to 1.04)	0.97 (0.91 to 1.04)	0.90 (0.87 to 0.94)	0.92 (0.89 to 0.96)	0.92 (0.88 to 0.95)
Physical symptoms	1.27 (1.21 to 1.33)	1.26 (1.20 to 1.33)	1.25 (1.19 to 1.32)	1.15 (1.12 to 1.19)	1.14 (1.10 to 1.17)	1.13 (1.10 to 1.17)
Social Support						
Superiors' support	1.02 (0.98 to 1.07)	1.01 (0.96 to 1.06)	1.01 (0.96 to 1.06)	0.94 (0.91 to 0.97)	0.93 (0.90 to 0.96)	0.93 (0.90 to 0.96)
Co-workers' support	0.91 (0.87 to 0.96)	0.91 (0.87 to 0.95)	0.92 (0.88 to 0.97)	0.86 (0.83 to 0.88)	0.84 (0.82 to 0.87)	0.85 (0.82 to 0.88)
Family support	1.15 (1.10 to 1.19)	1.13 (1.09 to 1.18)	1.13 (1.09 to 1.18)	1.11 (1.08 to 1.14)	1.11 (1.09 to 1.14)	1.12 (1.10 to 1.15)

Model 0: logistic analysis not adjusted.
Model 1: logistic analysis adjusted by age and body mass index (BMI).
Model 2: logistic analysis adjusted by age, BMI, amount of alcohol consumption and frequency of alcohol consumption.
BJSQ, Brief Job Stress Questionnaire.

Table 3 ORs of smoking to not smoking for the BJSQ subscale combinations highly associated with smoking

Physical symptoms	Irritation	Physical burden	OR (95% CI) Women	OR (95% CI) Men
(–)	(–)	(–)	1.00	1.00
(–)	(–)	(+)	1.36 (1.18 to 1.56)	1.27 (1.19 to 1.36)
(+)	(–)	(–)	1.47 (1.25 to 1.73)	1.16 (1.05 to 1.28)
(–)	(+)	(–)	1.53 (1.28 to 1.82)	1.35 (1.24 to 1.47)
(–)	(+)	(+)	1.73 (1.47 to 2.03)	1.52 (1.41 to 1.65)
(+)	(–)	(+)	1.93 (1.66 to 2.23)	1.66 (1.52 to 1.81)
(+)	(+)	(–)	2.06 (1.79 to 2.38)	1.45 (1.33 to 1.58)
(+)	(+)	(+)	2.63 (2.31 to 3.00)	1.79 (1.67 to 1.93)

(+) Positive Z-score. (–) Negative Z-score.
BJSQ, Brief Job Stress Questionnaire.

DISCUSSION

This is the first large-scale study to investigate a wide range of components of occupational stress and smoking intensity using the BJSQ. We have clarified occupational stress specific to smokers on the following three points. (1) Subscales independently associated with smoking in both genders were 'physical burden', 'irritation' and 'physical symptoms'. However, since there was no synergistic effect of these three major stress subscales, we felt it was not important to prioritise addressing this stressor or stress

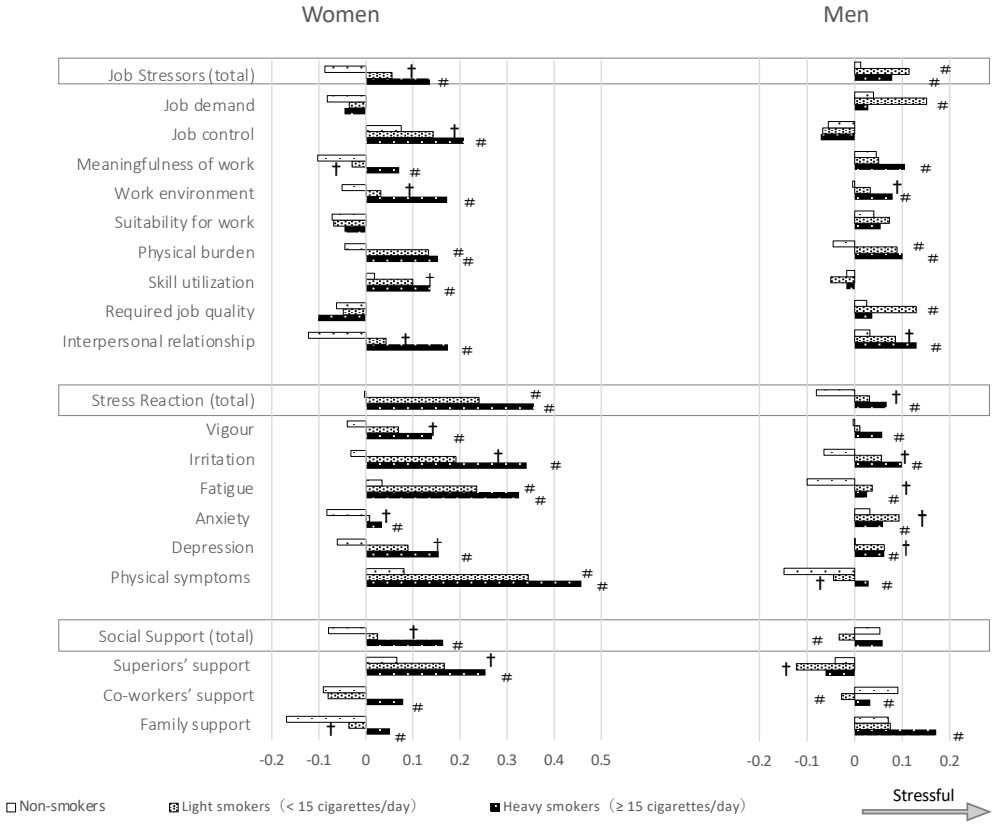

Figure 1 Z-scores of components and subscales on the Brief Job Stress Questionnaire (BJSQ) by participants grouped according to smoking intensity. †P<0.05 versus non-smokers (Dunnett's test only). #P<0.05 versus non-smokers (Dunnett's test and multivariate analysis adjusted for age, body mass index, amount of alcohol consumption and frequency of alcohol consumption).

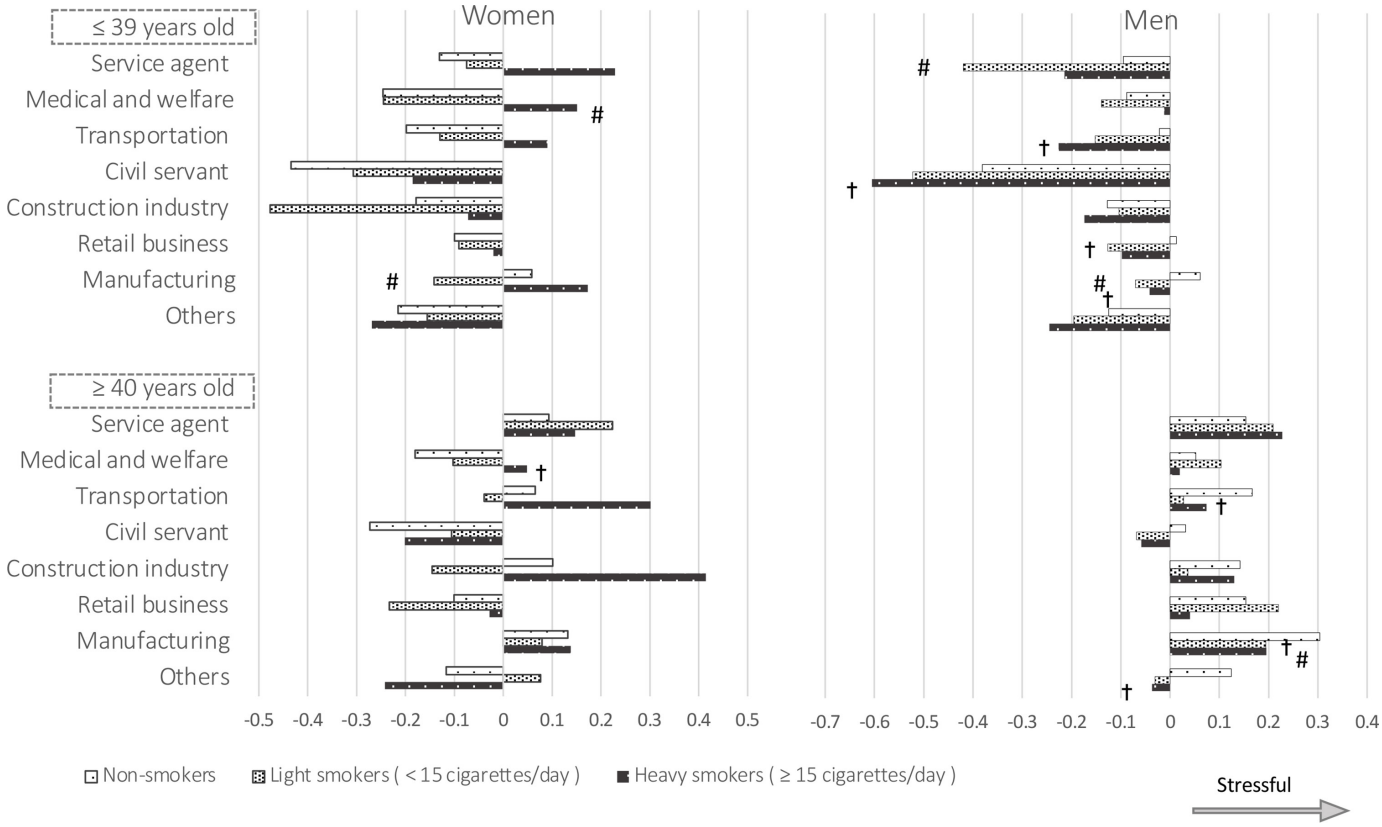

Figure 2 Z-scores of 'co-workers' support' subscale on the Brief Job Stress Questionnaire (BJSQ) by participants grouped according to smoking intensity, age group (≥40 and ≤39 years) and main industries. †P<0.05 versus non-smokers (Dunnett's test only). #P<0.05 versus non-smokers (Dunnett's test and multivariate analysis adjusted for body mass index, amount of alcohol consumption and frequency of alcohol consumption).

response in the workplace. (2) HS women were generally highly stressed. (3) LS men obtained more 'co-workers' support' even though they had higher stressors such as 'job demands'. As hypothesised, the larger the amount of smoking in women, the greater the stress in all three components of 'Job Stressors', 'Stress Reactions' and 'Social Support'. But in men, smoking intensity and social support did not support the hypothesis. The reason why smoking status was strongly associated with 'physical burden' rather than 'job demands' is that 'small breaks to rest the body' may be strongly linked to smoking and become a habit in the manufacturing, transport and construction industries in men. The high rate of smoking in these occupations has already been shown in a survey of medium-sized and small-sized companies in Japan.[15] 'Job demands' primarily identifies the degree of psychological burden whereas 'physical burden' was evaluated by only one question asking whether the work involved physical labour. In an earlier occupation-specific survey, Strickland and colleagues reported nearly twice the rate of smoking among white construction workers compared with whites in general in Missouri, USA.[32] Chau and colleagues examined the work content in assessing 'physical job demands' and reported that workers with a higher total amount of physical work, such as 'working under bad weather' and 'using vibration tools', smoked greater numbers of cigarettes in the Lorene region of France.[33] This is probably because such workers often work on the same team and recognise smoking as a 'means of dealing with work difficulties'. Furthermore, smokers recognise that smoking can relieve the 'irritation' that they feel as occupational stress, but this 'irritation' can also occur as symptom of nicotine withdrawal due to a temporary interruption of smoking during work.[34] In addition, nicotine withdrawal can be manifested by dizziness and palpitations. In a review, Parrott stated that smokers tended to report high 'daily' stress and that stress symptoms such as irritation increase when they cannot smoke frequently, and that successful quitters experience reduced 'stress'.[35] Strictly speaking, these complaints by smokers may not be 'physical symptoms' of occupational stress.

The reasons why HS women were highly stressed are complex. HS women generally have high scores for 'Job Stressors' such as 'job control', 'work environment' and 'interpersonal relationships', and they may be engaged in low discretionary tasks in the first place. In addition, it was shown that women smokers not only workers in general were more likely than men to express negative emotions, such as anxiety, regarding the stress response[36]; biological and socioenvironmental 'sex differences' are being explored.[37] Tomioka *et al*[18] suggested the necessity of coping with psychological distress as a smoking cessation measure for Japanese women, including the non-regularly employed and unemployed. Our results suggest

that coping with stress symptoms may also be useful for smoking cessation among regularly employed women who are more financially stable. Similarly, the results of 'Social Support' suggested that HS women engaged in tasks with less support than NS. Conversely, the stress caused by lack of social support may have led women to smoke. Creswell and colleagues reported that, in general, 'social support' aided in the success of smoking cessation.[38]

In men, there might be a kind of 'social smoking' because smokers reported better 'Social Support' than NS. Earlier reports captured the phenomenon that college student smokers smoked only when with friends and acquaintances,[39 40] and the presence of youth who habitually smoked only on social occasions, such as at parties, became recognised. They were reported to display positive actions in preventing secondhand smoking by NS.[41] Even in Japan, smokers who 'do not smoke at home' exist, and their restrained smoking style was reported.[42] This type of smoking, which is highly related to peers, has been defined as 'peer smoking'.[33 43] The results for 'co-worker's support' suggest that LS are more likely to be social smokers, especially in the service and manufacturing industries. LS men and women in the manufacturing industry had significantly better coworkers' support than NS. This means that LS in these industries may feel closer to their co-workers when they smoke.

Research on social support and smoking in the workplace suggested that smoking functioned as a communication tool. In China, where the smoking rate is as high as 38%, it is highly speculated that supervisors and coworkers are smokers, so smokers are more likely to obtain support by supervisors.[44] A study in North America reported (smoking rate: 26%) that supervisors' support inhibited smoking, but coworkers' support did not.[45] In addition, a study of civil servant Brazilian men (smoking rate: 17%) reported that social support suppressed smoking.[46] Thus, the association between 'social support' and smoking may be explained by differences in the workplace smoking rate, with better relationships between NS in environments with a low smoking rate and better communication between smokers in workplaces with high smoking rates. LS men probably have sufficient knowledge about the health hazards of smoking to suppress their smoking intensity. However, they may be psychologically unable or fail to initiate smoking cessation because they may be afraid of losing social support in a workplace with a high smoking rate. Indeed, interventional surveys of smoking cessation guidance have reported that workplaces with a higher percentage of smokers have a stronger impact on peer smoking behaviour and lower rates of long-term smoking cessation.[43]

Smoking rates may also be a factor in 'co-workers' support' scores. Among women, 'co-workers' support' was better for LS than NS in the manufacturing industry. The smoking rate among women in the manufacturing industry was relatively high at 15.8%, and it is estimated that women obtain 'co-workers' support' through smoking in such workplaces. These findings seemed to mean that good communication through smoking in a workplace could occur if the smoking rate was relatively high. In addition, the relationship between coworker support and smoking intensity within industries may differ depending on work duties. In health and social work, smoking is perceived as undesirable, and HS who take frequent smoking breaks are imagined to have reduced communication with colleagues. Promoting smoking cessation among youth is desirable for their health, and smoking regulations may be acceptable especially for young social smokers due to their behavioural characteristics. Common social smoking measures in workplaces include bans on smoking on workplace premises and during working hours.[47] Simultaneously, it is necessary to promote communication among workers in the workplace, even under a non-smoking environment. Alternatives to smoking that promote informal communication include taking short breaks, increasing opportunities for face-to-face conversations and increasing opportunities for interaction with workers in other departments based on the benefits that smokers have received.[48]

Significance and limitations of this study

The strength of this study is that it was a large comprehensive occupational stress survey of employed individuals in East Asia. Therefore, this study could investigate the association between a wide range of occupational stresses and smoking intensity across multiple occupations, suggesting for the first time that workplace stressors and supportive conditions may differ according to smoking rates in workplaces and by gender.

A limitation of this study is that it was cross-sectional and therefore causal relationships could not be identified. Factors such as working hours, job position and company size, which could not be surveyed at this time, may have contributed to the association between smoking and physical burden. Also, because the number of cigarettes smoked was provided by self-report in a health check-up questionnaire, responses may be inaccurate, such as inputting less than the actual dose. Reports by users of electronic cigarettes and heated tobacco product users may not have been accurate because it is difficult to translate these products into the number of cigarettes smoked or because users are not aware of them as tobacco products.

CONCLUSIONS

The occupational stress of smokers of both genders may be related to the subjective 'physical burden', 'irritation' and 'physical symptoms'. In analyses of smoking intensity and gender, both strong psychosomatic stress symptoms such as 'irritation' and 'physical symptoms' and lack of social support at work were observed in HS women; however, in contrast, over AS, 'co-workers' support' was good in men. In addition, in young LS women in the manufacturing industries, where the smoking rate is relatively high, we observed significantly better 'co-workers'

support' compared with that in NS, suggesting the presence of 'social smokers' who continue to smoke small amounts as a communication tool in these workplaces.

These results suggest that improvement of the communication environment among workers may be essential for the promotion of smoking cessation at the same time as smoking bans in worksites and public facilities.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not required.

Ethics approval This study involves human participants and was approved by the Ethics Committee of Niigata University (2017-0401), and we have obtained consent for the use of personal information from all participants on the health check-up. After confirming the concordance of the data, personal information such as the participant's name, personal identification code for health check-up orders and the name of the company or office to which the worker belonged was removed before using the data for analysis. This study does not involve animal subjects. Participants gave informed consent to participate in the study before taking part.

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Supplemental Table 1. BJSQ simple total score by smoking intensity group: 3 components and 18 subscales

BJSQ Stress components & subscales	Range of points	Women				Men			
		Non-smokers (NS) <control>	smokers			Non-smokers (NS) <control>	Smokers		
			All smokers (AS)	Light smokers (LS)	Heavy smokers (HS)		All smokers (AS)	Light smokers (LS)	Heavy smokers (HS)
		average (SD)				average (SD)			
Job Stressors (total)	17-68	41.3 (6.8)	42.4 (6.9) [ac]	42.3 (6.8) [b]	42.8 (7.1) [bc]	42.0 (6.8)	42.5 (6.7) [ac]	42.7 (6.6) [bc]	42.4 (6.7) [bc]
Job demands	3-12	8.0 (2.1)	8.1 (2.1) [ac]	8.1 (2.0)	8.1 (2.1)	8.3 (2.1)	8.4 (2.0) [ac]	8.5 (2.0) [bc]	8.3 (2.1)
Job control	3-12	7.8 (2.0)	8.0 (2.1) [ac]	8.0 (2.1) [b]	8.1 (2.1) [bc]	7.6 (2.0)	7.5 (2.0)	7.5 (2.0)	7.5 (2.0)
Meaningfulness of work	1-4	2.1 (0.8)	2.2 (0.8) [ac]	2.2 (0.8) [b]	2.3 (0.9) [bc]	2.2 (0.8)	2.3 (0.8) [ac]	2.2 (0.8)	2.3 (0.8) [bc]
Work environment	1-4	2.3 (1.0)	2.4 (1.0) [ac]	2.3 (1.0) [b]	2.5 (1.0) [bc]	2.3 (1.0)	2.4 (1.0) [ac]	2.3 (1.0) [b]	2.4 (1.0) [bc]
Suitability for work	1-4	2.1 (0.7)	2.1 (0.8)	2.1 (0.7)	2.1 (0.8)	2.2 (0.8)	2.2 (0.8)	2.2 (0.8)	2.2 (0.8)
Physical burden	1-4	2.5 (1.1)	2.7 (1.0) [ac]	2.7 (1.0) [bc]	2.7 (1.0) [bc]	2.5 (1.0)	2.7 (1.0) [ac]	2.7 (1.0) [bc]	2.7 (1.0) [bc]
Skill utilization	1-4	2.2 (0.8)	2.2 (0.8) [ac]	2.2 (0.8) [b]	2.3 (0.8) [bc]	2.1 (0.8)	2.1 (0.8)	2.1 (0.8)	2.1 (0.8)
Required job quality	3-12	8.2 (2.0)	8.2 (2.0)	8.2 (2.0)	8.1 (2.0)	8.4 (1.9)	8.5 (1.9) [ac]	8.6 (1.9) [bc]	8.4 (1.9)
Interpersonal relationship	3-12	6.0 (1.9)	6.4 (2.0) [ac]	6.3 (2.0) [b]	6.6 (2.0) [bc]	6.3 (1.9)	6.5 (1.9) [ac]	6.4 (1.9) [b]	6.5 (1.9) [bc]
Stress Reaction (total)	29-116	57.4 (14.4)	61.5 (15.4) [ac]	61.0 (15.2) [bc]	62.7 (15.7) [bc]	56.3 (14.6)	58.3 (14.6) [ac]	57.9 (14.6) [b]	58.5 (14.6) [bc]
Vigor	3-12	8.5 (2.4)	8.8 (2.4) [ac]	8.7 (2.4) [b]	8.9 (2.4) [bc]	8.5 (2.3)	8.6 (2.2) [ac]	8.6 (2.2)	8.7 (2.2) [bc]
Irritation	3-12	6.4 (2.4)	7.1 (2.5) [ac]	6.9 (2.5) [b]	7.3 (2.5) [bc]	6.3 (2.4)	6.7 (2.4) [ac]	6.6 (2.4) [b]	6.7 (2.4) [bc]
Fatigue	3-12	6.9 (2.5)	7.4 (2.6) [ac]	7.4 (2.6) [bc]	7.6 (2.6) [bc]	6.5 (2.4)	6.9 (2.4) [ac]	6.9 (2.4) [b]	6.8 (2.4) [bc]
Anxiety	3-12	5.9 (2.3)	6.2 (2.4) [ac]	6.1 (2.3) [b]	6.2 (2.4) [bc]	6.2 (2.3)	6.3 (2.3) [ac]	6.3 (2.3) [b]	6.3 (2.3) [bc]
Depression	6-24	10.2 (3.7)	10.8 (3.9) [ac]	10.8 (3.9) [b]	11.0 (3.9) [bc]	10.4 (3.9)	10.7 (3.8) [ac]	10.7 (3.8) [b]	10.7 (3.9) [bc]
Physical symptoms	11-44	19.6 (5.5)	21.3 (6.1) [ac]	21.1 (6.1) [bc]	21.7 (6.2) [bc]	18.3 (5.6)	19.1 (5.8) [ac]	18.9 (5.8) [b]	19.3 (5.8) [bc]
Social Support (total)	9-36	19.7 (4.9)	20.4 (5.0) [ac]	20.2 (5.1) [b]	20.9 (4.9) [bc]	20.4 (5.1)	20.2 (5.1) [ac]	19.9 (5.1) [bc]	20.4 (5.2)
Superiors' support	3-12	7.9 (2.2)	8.2 (2.3) [ac]	8.1 (2.3) [b]	8.3 (2.2) [bc]	7.7 (2.2)	7.6 (2.2) [ac]	7.5 (2.2) [b]	7.6 (2.2)
Co-workers' support	3-12	6.8 (2.1)	6.9 (2.1) [ac]	6.8 (2.2)	7.1 (2.1) [bc]	7.2 (2.0)	7.0 (2.0) [ac]	6.9 (2.1) [bc]	7.0 (2.0) [bc]
Family support	3-12	5.0 (2.0)	5.4 (2.2) [ac]	5.3 (2.2) [b]	5.5 (2.2) [bc]	5.5 (2.2)	5.7 (2.2) [ac]	5.5 (2.2)	5.7 (2.2) [bc]

BJSQ: Brief Job Stress Questionnaire,

[a] p <0.05 vs non-smokers (unpaired t test), [b] p<0.05 vs non-smokers (Dunnett's test),

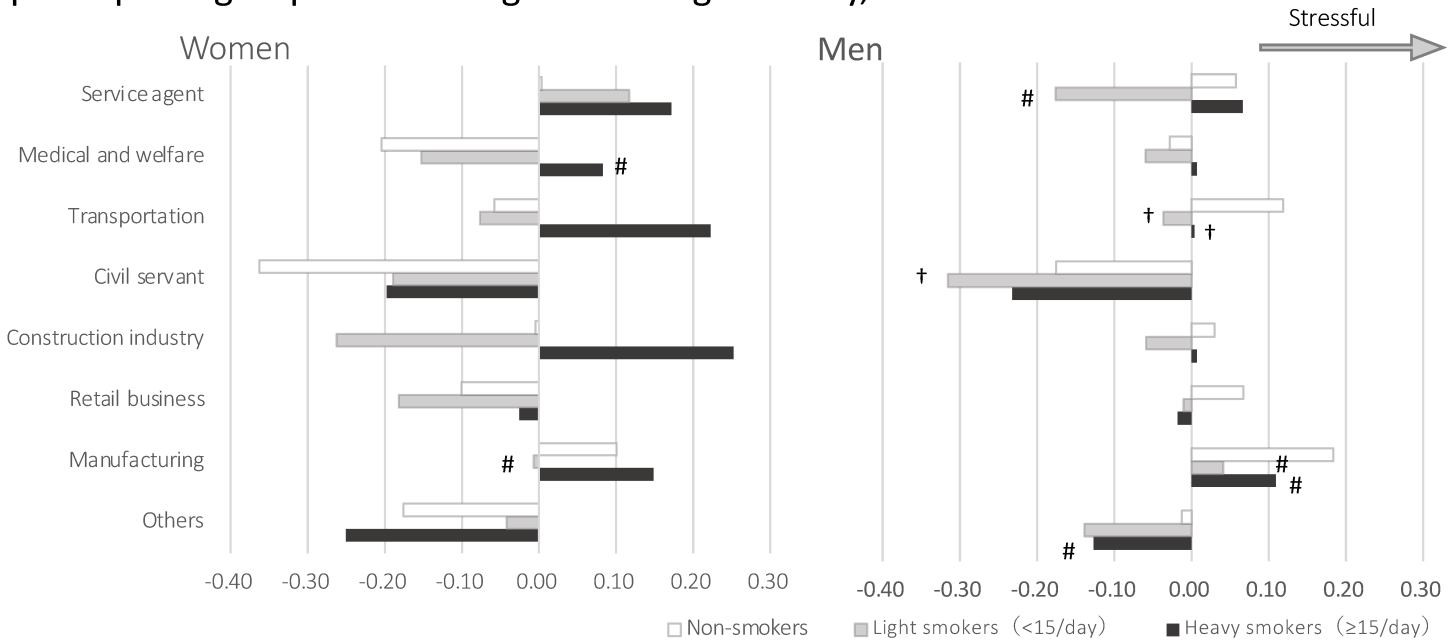
[c] p<0.05 vs non-smokers (multivariate analysis adjusted with age, BMI, amount of alcohol consumption, frequency of alcohol consumption)

BMI: body mass index

[Light smokers (LS) <15 cigarettes/day, Heavy smokers (HS) ≥15 cigarettes/day]

Supplemental Fugure1

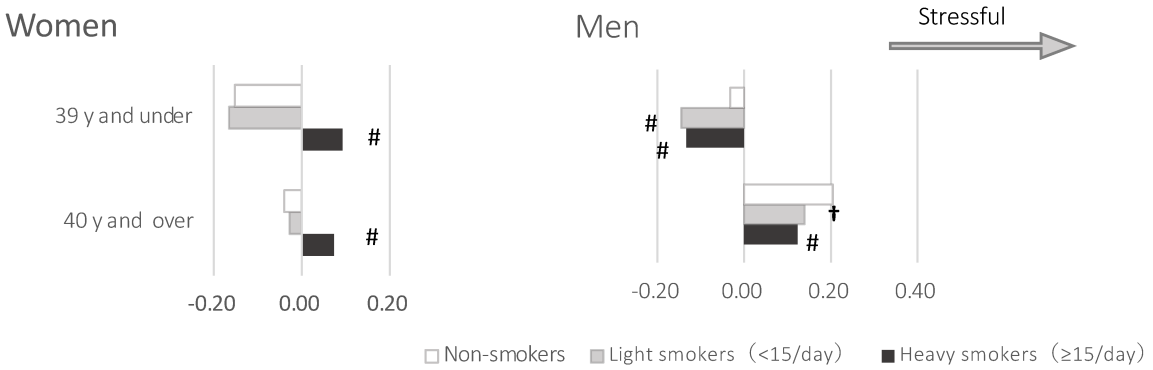
Z-scores of “co-workers’ support” subscale on the Brief Job Stress Questionnaire (BSJQ) by participants grouped according to smoking intensity, and main industries.



† : P<0.05 vs. non-smokers (Dunnett’s test only),
#: p<0.05 vs. non-smokers (Dunnett’s test and multivariate analysis adjusted for age, body mass index, amount of alcohol consumption, and frequency of alcohol consumption)

Supplemental Fugure2

Z-scores of “co-workers’ support” subscale on the Brief Job Stress Questionnaire (BSJQ) by participants grouped according to smoking intensity, and age group (≥40 y and ≤39 y)



†: p<0.05 vs. non-smokers (Dunnett’s test only),
#: p<0.05 vs. non-smokers (Dunnett’s test and multivariate analysis adjusted for body mass index, amount of alcohol consumption, and frequency of alcohol consumption)
y: years old