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The Relationship between Insomnia and Lifestyle-Related Diseases among Japanese Male Truck Drivers

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Previously, insomnia and adverse lifestyle were prevalent among truck drivers, but the association between the two remains unknown in this particular occupational cohort. This study aimed to examine the relationship between insomnia and lifestyle-related diseases among truck drivers. We investigated 875 male truck drivers of the Japan Truck Association, Akita branch, as of July 2020. The definition of insomnia was based on the International Classification of Sleep Disorders, Third Edition (ICSD-3). Data from a self-administered questionnaire were merged with health records and health insurance claims data of 2020. In total, 40.1% had either one of the lifestyle-related diseases including hypertension (29.7%), diabetes mellitus (11.7%), and dyslipidemia (24.8%), whereas according to ICSD-3, 13.2% had insomnia. Multivariate logistic regression models demonstrated that individuals with insomnia had approximately 2-fold increased risk of having at least one lifestyle-related disease ($p < 0.001$), hypertension ($p = 0.0027$), diabetes mellitus ($p = 0.0654$) and dyslipidemia ($p < 0.001$). Occupational characteristics including daily driving hours, driving distance, and travel days were not associated with any lifestyle-related diseases except for an association between short-haul and at least one disease. In conclusion, insomnia is significantly associated with increased risks of lifestyle-related diseases among male truck drivers in Japan.

Keywords: dyslipidemia; hypertension; insomnia; lifestyle-related diseases; truck drivers
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Introduction

With the development of online shopping systems, the demand for road transportation has rapidly increased. The coronavirus disease 2019 pandemic and its consequence of "stay at home" order also resulted in significant growth of parcel deliveries (UNCTAD, United Nations Conference on Trade and Development 2021). In this context, truck drivers play a vital role in the current economy. However, ensuring a workforce in an aging society is difficult; thus, the industry is faced with a serious shortage of labor and presence of elderly drivers (Ministry of Internal Affairs and Communications 2022). Certainly, over 70% of Japanese active truck drivers are aged over 40 years, whereas those aged under 29 years account for only 10% of the same population (Ministry of Internal Affairs and Communications 2022). The shortage of workforce has placed truck drivers under heavy workloads, such as prolonged and irregular shifts (Ministry of Health, Labour and Welfare of Japan 2018), where insomnia is significantly more prevalent than estimated for the general population (Brito et al. 2021).

Insomnia is considered a major health problem among truck drivers because it can cause traffic accidents (Lombardi et al. 2010). Recent studies have demonstrated that insomnia is highly associated with lifestyle-related diseases, such as hypertension (Gangwisch et al. 2006), diabetes mellitus (Ogilvie and Patel 2018), and dyslipidemia in the general population (Troxel et al. 2010). A few studies have suggested that disturbed sleep due to insomnia results in fluctuations in appetite regulatory hormone levels and activation of the hypothalamic-pituitary-adrenal axis (Taheri et al. 2004; Balbo et al. 2010). Furthermore, occupational

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characteristics of truck drivers may exacerbate lifestyle-related diseases induced by sleep difficulty (Taheri et al. 2004; Gangwisch et al. 2006; Troxel et al. 2010; Balbo et al. 2010) such as smoking, drinking, lack of physical activities, compulsory sedentary work, and unhealthy eating habits (Hege et al. 2019; Guest et al. 2020). These underlying conditions may additionally increase the risk of developing life-threatening diseases, such as stroke and myocardial infarction, but the evidence is limited as to whether insomnia is related to lifestyle-related diseases among this particular occupational cohort. The report of the Ministry of Land, Infrastructure, Transport and Tourism, Road Transport Bureau (2021) showed that the number of cases of disease onset while driving among commercial truck drivers is increasing annually, and this area of study needs to be accelerated. Therefore, we conducted a study to examine the relationship between insomnia and lifestyle-related diseases such as hypertension, diabetes mellitus, and dyslipidemia among Japanese truck drivers, setting insomnia as the main exposure and work characteristics as covariates.

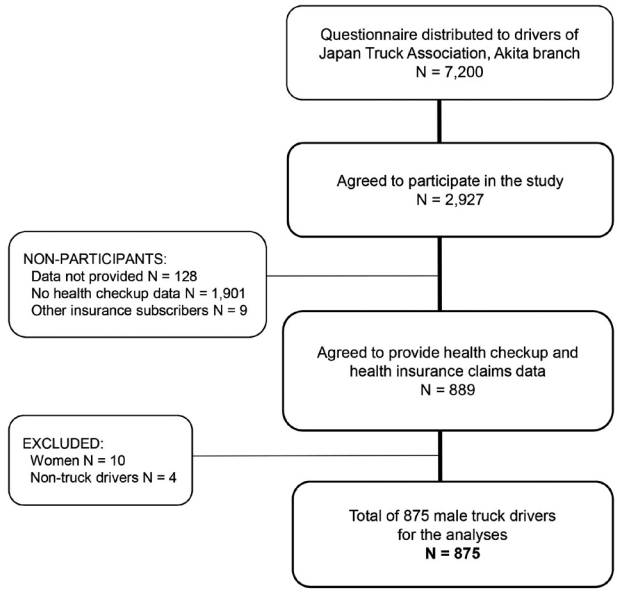

Fig. 1. Flowchart of study enrollments.

Materials and Methods

Participants

This cross-sectional study was a joint research project with the Japan Truck Association, Akita prefectural branch, and the Japan Health Insurance Association, Akita branch. Although the details of the data collection methods have been described elsewhere (Miyachi et al. 2021), we briefly describe these details here. At the time of investigation in July 2020, companies belonging to the Japan Truck Association, Akita prefectural branch had 7,200 trucks in total. Thus, we distributed the same numbers of the written informed consent embedded in the self-administered questionnaire. Then, in September 2020, 2,927 drivers responded to a self-administered questionnaire. Of these, we identified 899 individuals whose annual health check-up data and health insurance claims were stored in the database of the Insurance Association and who also agreed to provide the data. We further excluded women (n = 10) and non-truck drivers (n = 4), leaving a total of 875 male truck drivers for the analyses (Fig. 1).

Health records of 2020

In Japan, employers are required to perform medical examinations for workers annually as a regular health check-up. The check-up includes height and weight assessment, medical history, blood pressure measurement, blood test for plasma glucose and lipid level assessment, liver and kidney function, urine test, electrocardiogram, chest X-ray, and a general health discussion with a doctor. In this study, we obtained individual health check-up records of height, weight, and blood tests measured in 2020, the same year of insomnia investigation based on the self-administered questionnaire.

Health insurance claim data of 2020

The outcome of our study was at least one or individual lifestyle-related diseases, including hypertension, diabetes mellitus, and dyslipidemia, ascertained from medical records. These data were derived from health insurance claims in 2020 and defined if an insured person visited any medical institutions under the particular names of life-related diseases and/or received treatment (i.e., medicine) under the same diseases. These data were provided by the Japan Health Insurance Association, Akita branch.

Self-administered questionnaire distributed in 2020

We developed a health questionnaire which was distributed to truck drivers in 2020. The items investigated were insomnia symptoms, occupational characteristics, and covariates.

Insomnia symptoms

We slightly modified the definition of insomnia based on the International Classification of Sleep Disorders, Third Edition (ICSD-3). Insomnia symptoms included difficulty initiating sleep, difficulty maintaining sleep, and episodes of early morning awakening. Difficulty initiating sleep was defined as difficulty falling asleep at night and took more than 2 h before sleep. Difficulty maintaining sleep was defined as waking up twice or more during the night. Early morning awakening was defined waking up 2 h earlier than desired and unable to fall asleep again. Participants were asked if they had daytime tiredness defined as still feeling tired or fatigued the day following the insomnia symptoms observed. Daytime tiredness was measured on a 4-point Likert scale (never, rarely, often, always). Insomnia was defined as the presence of any of the three insomnia symptoms at least three times a week over a 3-month period in

combination with often or always experiencing daytime tiredness. In addition, we asked for self-reported sleeping times.

Occupational characteristics

We measured occupational characteristics of driving distance, daily driving hours, and travel days. Continuous variables of daily driving hours and travel days were categorized into binary (< 8 h vs. ≥ 8 h) and the number of business day trips (not applicable / two-business day trip / three or more-business day trip). For driving distance, participants were grouped into three categories (long haul / middle haul / short haul) based on the area in which they drove. Short-haul drivers worked mainly within the Akita prefecture (local district unit), middle-haul drivers worked within the Tohoku region (one of Japan's five geographic areas to which Akita prefecture belongs), and long-haul drivers worked without boundaries.

Covariates

Covariates investigated in the questionnaire included age, sex, body mass index (BMI) (non-obese: < 25 kg/m^2 vs. obese: ≥ 25 kg/m^2), and lifestyle habits. Lifestyle habits investigated included smoking (never vs. past vs. current), drinking, and caffeine consumption. For drinking habits, participants were asked about their weekly frequency and daily alcohol amount on the basis of '*go'*, which is an alcohol measuring scale often used in Japan. A '*go'* means 180 mL of Japanese *sake* and contains 22 g of ethanol, which is equivalent to a glass of wine (120 mL), a bottle of beer (500 mL), and a double-shot whiskey (120 mL). Weekly alcohol consumption was calculated by multiplying the weekly frequency with daily ethanol consumption. Based on the weekly amount of alcohol consumption, participants were further divided into three groups: non-drinkers, normal drinkers (< 322 g/week), and heavy drinkers (≥ 322 g/week). Caffeinated beverages and foods were measured by weekly caffeine consumption of tea, such as green tea, Oolong tea (semi-fermented tea), black tea (fermented tea), coffee, energy drinks, caffeinated chewing gum, caffeinated tablets, and caffeine drops. Participants were asked about their daily cups (one cup was converted into 150 mL) of each beverage and the number of tablets consumed in addition to the weekly frequency. Information about the amount of caffeine in each beverage and food was obtained from the Food Safety Commission of Japan (2018) and from each manufacturer. Weekly caffeine consumption was then calculated by multiplying daily caffeine consumption by weekly frequency. Participants were divided into two groups (normal: ≤ 2,800 mg/week, heavy: > 2,800 mg/week) based on their caffeine consumption per week (Nawrot et al. 2003).

Statistical analyses

For creating a dataset for analyses, we merged self-administered questionnaire data with health records and health insurance claim data of 2020. First, we tested an association between each lifestyle-related disease (hypertension, diabetes mellitus, and dyslipidemia) and variables using a t-test or chi-squared test according to the distribution of each variable. A logistic regression model was then used to investigate the association of insomnia with each lifestyle-related disease and at least one disease. Odds ratios (ORs) were computed with 95% confidence intervals (95% CIs). Multivariate logistic analyses were performed by using stepwise selection methods. Missing variables included drinking habits (n = 18), smoking habits (n = 7), daily driving hours (n = 12), driving distance (n = 6), travel days (n = 29), insomnia (n = 3), and fasting blood sugar (BS) levels (n = 212). We first confirmed the missing at random and then we imputed these missing data with the multivariate imputation by Chained Equations algorithm, creating 50 multiply imputed data sets. The results of the analysis of covariance were combined by averaging, and standard errors were adjusted to reflect both within-imputation variability and between-imputation variability using Rubin's rules (Little and Rubin 2019).

All analyses were performed using R software (version 3.6.1; R Foundation for Statistical Computing, Vienna, Austria). All tests were two-sided, and statistical significance was set at $p < 0.05$.

Ethical approval

This study was approved by the Medical Ethical Committee of the University of Akita (approval number: 2456) and conducted in accordance with the Declaration of Helsinki. All participants provided informed consent to participate in this study. This study is supported by Japan Organization of Occupational Health and Safety, Akita Occupational Health Support Center (No.2021_19) and the Japan Health Insurance Association, Akita branch.

Results

Characteristics of male truck drivers

Table 1 presents the baseline characteristics of the 875 male truck drivers who participated in this analysis. The mean age and BMI were 52.5 ± 7.9 years and 24.9 ± 3.8 kg/m^2, respectively (mean ± standard deviation). Based on health insurance claims in 2020, 40.1% (n = 351) of truck drivers had either one of the lifestyle-related diseases, including hypertension (29.7%, n = 260), diabetes mellitus (11.7%, n = 104), and dyslipidemia (24.8%, n = 217), whereas 13.2% (n = 115) had insomnia. Truck drivers with lifestyle-related diseases were more likely to have insomnia, and have higher BMI, compared to drivers without lifestyle-related diseases. Heavy drinking habits were more likely to be observed in drivers with hypertension ($p < 0.001$). Caffeine consumption was not associated with any lifestyle-related diseases.

Table 1. Characteristics according to lifestyle-related diseases based on health insurance claims.

	The numbers of missing variables	At least one of lifestyle-related disease 40.1%, n = 351		Hyper tension 29.7%, n = 260		Diabetes mellitus 11.7%, n = 104		Dyslipidemia 24.8%, n = 217	
		(–)	(+)	(–)	(+)	(–)	(+)	(–)	(+)
Age[*,†,‡,§]	0	50.6 ± 7.5	55.3 ± 7.7	51.0 ± 7.6	56.0 ±7.4	51.9 ± 7.7	56.6 ± 8.1	51.8 ± 7.8	54.6 ± 7.9
Drinking habits[†]	18								
ethanol consumption (g/wk)[†]		232 ± 201	248 ± 210	221 ± 202	282 ± 206	243 ± 204	205 ± 207	246 ± 207	217 ± 198
non-drinker		109 (21.2)	69 (20.1)	144 (23.9)	34 (13.4)	151 (20.0)	27 (26.7)	127 (19.7)	51 (23.9)
normal (< 322 g/wk)		192 (37.4)	118 (34.4)	226 (37.5)	84 (33.1)	272 (36.0)	38 (37.6)	230 (35.7)	80 (37.6)
heavy (≥ 322 g/wk)		213 (41.4)	156 (45.5)	233 (38.6)	136 (53.5)	333 (44.1)	36 (35.6)	287 (44.6)	82 (38.5)
Caffeine consumption	0								
mg/wk		1,455 ± 997	1,406 ± 913	1,449 ± 982	1,405 ± 919	1,434 ± 966	1,454 ± 953	1,436 ± 983	1,435 ± 903
normal (≤ 2,800 mg/wk)		479 (91.4)	324 (92.3)	561 (91.2)	242 (93.1)	707 (91.7)	96 (92.3)	603 (91.6)	200 (92.2)
heavy (> 2,800 mg/wk)		45 (8.6)	27 (7.7)	54 (8.8)	18 (6.9)	64 (8.3)	8 (7.7)	55 (8.4)	17 (7.8)
Smoking habits[*,†,§]	7								
never		45 (8.7)	40 (11.5)	55 (9.1)	30 (11.5)	74 (9.7)	11 (10.7)	64 (9.8)	21 (9.7)
past		159 (30.6)	146 (41.8)	198 (32.6)	107 (41.2)	259 (33.9)	46 (44.7)	214 (32.8)	91 (42.1)
current		315 (60.7)	163 (46.7)	355 (58.4)	123 (47.3)	432 (56.5)	46 (44.7)	374 (57.4)	104 (48.2)
Body mass index[*,†,‡,§]	0								
kg/m^2[*,†,‡,§]		24.4 ± 3.5	25.8 ± 4.1	24.4 ± 3.5	26.1 ± 4.2	24.7 ± 3.5	26.7 ± 5.1	24.5 ± 3.5	26.2 ± 4.4
underweight (< 18.5 kg/m^2)		13 (2.5)	1 (0.3)	14 (2.3)	0 (0.0)	14 (1.8)	0 (0.0)	13 (2.0)	1 (0.5)
normal (18.5-25 kg/m^2)		317 (60.5)	163 (46.4)	368 (59.8)	112 (43.1)	440 (57.1)	40 (38.5)	389 (59.1)	91 (41.9)
obese (≥ 25 kg/m^2)		194 (37.0)	187 (53.3)	233 (37.9)	148 (56.9)	317 (41.1)	64 (61.5)	256 (38.9)	125 (57.6)
Daily driving hours	12								
< 8 h		306 (59.5)	206 (59.0)	359 (59.3)	153 (59.3)	455 (60.0)	57 (54.8)	386 (59.7)	126 (59.7)
≥ 8 h		208 (40.5)	143 (41.0)	246 (40.7)	105 (40.7)	304 (40.1)	47 (45.2)	261 (40.3)	90 (41.7)
Driving distance[*,†]	6								
short-haul (*Akita* prefecture)		288 (55.4)	237 (67.9)	342 (56.0)	183 (70.9)	453 (59.2)	72 (69.2)	387 (59.3)	138 (63.9)
middle-haul (*Tohoku* region)		115 (22.1)	52 (14.9)	129 (21.1)	38 (14.7)	151 (19.7)	16 (15.4)	131 (20.1)	36 (16.7)
long-haul (no boundary)		117 (22.5)	60 (17.2)	140 (22.9)	37 (14.3)	161 (21.1)	16 (15.4)	135 (20.7)	42 (19.4)
Travel days[†,‡]	29								
not applicable		328 (65.1)	248 (72.5)	387 (65.5)	189 (74.1)	496 (66.6)	80 (79.2)	425 (67.0)	151 (71.2)
two-business day		50 (9.9)	30 (8.8)	58 (9.8)	22 (8.6)	71 (9.5)	9 (8.9)	65 (10.3)	15 (7.1)
three or more-business day		126 (25.0)	64 (18.7)	146 (24.7)	44 (17.3)	178 (23.9)	12 (11.9)	144 (22.7)	46 (21.7)
Insomnia[*,†,‡,§]	3								
(+)		50 (9.6)	65 (18.6)	65 (10.6)	50 (19.3)	94 (12.2)	21 (20.2)	71 (10.8)	44 (20.4)
(–)		472 (90.4)	285 (81.4)	548 (89.4)	209 (80.7)	674 (87.8)	83 (79.8)	585 (89.2)	172 (79.6)
Sleep time	0								
≥ 6 h		459 (87.6)	309 (88.0)	537 (87.3)	231 (88.9)	679 (88.1)	89 (85.6)	579 (88.0)	189 (87.1)
< 6 h		65 (12.4)	42 (12.0)	78 (12.7)	29 (11.2)	92 (11.9)	15 (14.4)	79 (12.0)	28 (12.9)
Systolic blood pressure[*,†,‡,§]	0	130.6 ± 15.8	137.6 ± 16.8	130.5 ± 15.8	140.4 ± 16.2	132.8 ± 16.5	137.9 ± 16.7	132.7 ± 16.3	135.7 ± 17.2
Fasting blood sugar[*,†,‡,§]	212	100.6 ± 21.2	109.0 ± 26.6	102.2 ± 23.9	107.9 ± 23.0	100.5 ± 19.0	130.9 ± 37.1	101.9 ± 22.4	110.1 ± 26.9
Low-density lipoprotein[*,†]	0	122.8 ± 31.9	117.1 ± 32.1	123.7 ± 32.4	112.9 ± 30.0	121.1 ± 31.8	116.1 ± 34.1	121.0 ± 31.2	119.0 ± 34.5

Data are shown as mean ± standard deviation or n (%).

Based on a chi-squared test for categorical variables and a t-test for continuous variables.

[*]$p < 0.05$ for Lifestyle-related disease, [†]$p < 0.05$ for Hypertension, [‡]$p < 0.05$ for Diabetes mellitus, [§]$p < 0.05$ for Dyslipidemia.

Insomnia and lifestyle-related diseases, including hypertension, diabetes mellitus, and dyslipidemia: univariate logistic model

Table 2 shows the results of a univariate logistic analysis of insomnia and lifestyle-related diseases, including hypertension, diabetes mellitus, and dyslipidemia. It showed that insomnia was significantly associated with an increased risk of lifestyle-related diseases, hypertension, diabetes mellitus, and dyslipidemia, while increased age and obesity were also associated with an increased risk of each lifestyle-related disease or at least one disease. Travel days of three or more business days were associated with a

Table 2. Insomnia and lifestyle-related diseases, including hypertension, diabetes mellitus, and dyslipidemia: univariate logistic model.

	At least one of lifestyle-related disease		Hypertension		Diabetes mellitus		Dyslipidemia	
	crude OR (95% CI)	*p* value	crude OR (95% CI)	*p* value	crude OR (95% CI)	*p* value	crude OR (95% CI)	*p* value
Age†	1.09 (1.07-1.11)	< 0.0001	1.09 (1.07-1.11)	< 0.0001	1.08 (1.05-1.11)	< 0.0001	1.05 (1.03-1.07)	0.00
Drinking habits								
non-drinker	ref	0.50	ref	< 0.0001	ref	0.18	ref	0.24
normal (< 322 g/wk)	0.97 (0.67-1.42)		1.57 (1.00-2.47)		0.78 (0.46-1.33)		0.87 (0.57-1.31)	
heavy (≥ 322 g/wk)	1.16 (0.80-1.67)		2.47 (1.61-3.80)		0.61 (0.35-1.03)		0.71 (0.47-1.07)	
Caffeine consumption								
normal (≤ 2,800 mg/wk)	ref	0.64	ref	0.36	ref	0.83	ref	0.81
heavy (> 2,800 mg/wk)	0.89 (0.54-1.46)		0.77 (0.44-1.35)		0.92 (0.43-1.98)		0.93 (0.53-1.64)	
Smoking habits								
never	ref	0.00	ref	0.01	ref	0.07	ref	0.04
past	1.03 (0.64-1.67)		0.99 (0.60-1.64)		1.20 (0.59-2.42)		1.30 (0.75-2.25)	
current	0.58 (0.37-0.93)		0.64 (0.39-1.04)		0.72 (0.36-1.45)		0.85 (0.50-1.45)	
Body mass index	1.10 (1.06-1.15)	< 0.0001	1.12 (1.08-1.17)	< 0.0001	1.13 (1.07-1.18)	< 0.0001	1.12 (1.08-1.17)	< 0.0001
Daily driving hours								
< 8 h	ref	0.88	ref	0.99	ref	0.32	ref	0.73
≥ 8 h	1.02 (0.77-1.35)		1.00 (0.74-1.35)		1.23 (0.82-1.86)		1.06 (0.77-1.44)	
Driving distance								
short-haul (*Akita* prefecture)	1.61 (1.13-2.29)	< 0.0001	2.03 (1.35-3.03)	< 0.0001	1.60 (0.90-2.83)	< 0.0001	1.15 (0.77-1.71)	< 0.0001
middle-haul (*Tohoku* region)	0.88 (0.56-1.38)		1.12 (0.67-1.86)		1.07 (0.52-2.21)		0.88 (0.53-1.47)	
long-haul (no boundary)	ref		ref		ref		ref	
Travel days								
not applicable	ref	0.06	ref	0.04	ref	0.02	ref	0.34
two-business day	0.79 (0.49-1.29)		0.78 (0.46-1.31)		0.79 (0.38-1.64)		0.65 (0.36-1.17)	
three or more-business day	0.67 (0.48-0.95)		0.62 (0.42-0.90)		0.42 (0.22-0.79)		0.90 (0.62-1.32)	
Insomnia								
(+)	2.15 (1.45-3.20)	0.00	2.02 (1.35-3.01)	0.00	1.81 (1.07-3.07)	0.03	2.11 (1.40-3.19)	0.00
(–)	ref		ref		ref		ref	
Sleep time								
≥ 6 h	ref	0.85	ref	0.53	ref	0.47	ref	0.73
< 6 h	0.96 (0.64-1.45)		0.86 (0.55-1.36)		1.24 (0.69-2.24)		1.09 (0.69-1.72)	
Systolic blood pressure‡	1.03 (1.02-1.04)	< 0.0001	1.04 (1.03-1.05)	< 0.0001				
Fasting blood sugar‡	1.02 (1.01-1.02)	< 0.0001			1.04 (1.03-1.05)	< 0.0001		
Low-density lipoprotein‡	0.99 (0.99-1.00)	0.30					1.00 (0.99-1.00)	0.00

OR, odds ratio; CI, confidence interval.
†Based on unit 10, ‡Based on unit 5.

decreased risk of hypertension and diabetes mellitus. A five-unit increase in systolic blood pressure levels and fasting BS levels was associated with an increased risk for hypertension and diabetes mellitus, respectively.

Insomnia and lifestyle-related diseases, including hypertension, diabetes mellitus, and dyslipidemia: multivariate logistic model after multiple imputation

Multivariate logistic analyses with multiple imputation, of insomnia and lifestyle-related diseases, including hypertension, diabetes mellitus, and dyslipidemia, are shown in Table 3 and Figs. 2, 3, 4 and 5. After adjusting for covariates, truck drivers with insomnia were approximately 2-fold more likely to have at least one lifestyle-related disease (OR 2.25, 95% CI 1.46-3.47, Fig. 2), hypertension (OR 1.99, 95% CI 1.29-3.10, Fig. 3), and dyslipidemia (OR 2.13, 95% CI 1.40-3.24, Fig. 5). The relationship between insomnia and diabetes mellitus was marginally significant (OR 1.76, 95% CI 0.97-3.20, $p = 0.0654$, Fig. 4). Significant covariates associated with an increased risk for lifestyle-related diseases included increased age (all $p < 0.001$). For smoking, there were no association with lifestyle-related diseases, whereas heavy drinking habits had an association with hypertension (OR 2.18, 95% CI 1.37-3.47). Short-haul driving distance compared to long-haul was associated with an increased risk of

Table 3. Insomnia and lifestyle-related diseases including hypertension, diabetes mellitus, and dyslipidemia by multivariate logistic model with multiple imputation (n = 875).

	At least one of lifestyle-related disease	Hypertension	Diabetes mellitus	Dyslipidemia
	Adjusted OR (95% CI)	Adjusted OR (95% CI)	Adjusted OR (95% CI)	Adjusted OR (95% CI)
Age†	1.09 (1.06-1.11)	1.08 (1.05-1.10)	1.06 (1.03-1.10)	1.05 (1.03-1.07)
Drinking habits	-		-	-
non-drinker		ref		
normal (< 322 g/wk)		1.48 (0.91-2.42)		
heavy (≥ 322 g/wk)		2.18 (1.37-3.47)		
Caffeine consumption	-	-	-	-
normal (≤ 2,800 mg/wk)				
heavy (> 2,800 mg/wk)				
Smoking habits	-	-	-	-
never				
past				
current				
Body mass index	1.12 (1.07-1.16)	-	-	-
Daily driving hours	-	-	-	-
< 8 h				
≥ 8 h				
Driving distance		-	-	-
short-haul (*Akita* prefecture)	1.50 (1.02-2.21)			
middle-haul (*Tohoku* region)	0.89 (0.55-1.45)			
long-haul (no boundary)	ref			
Travel days	-	-	-	-
not applicable				
two-business day				
three or more-business day				
Insomnia				
(+)	2.25 (1.46-3.47)	1.99 (1.29-3.10)	1.76 (0.97-3.20)	2.13 (1.40-3.24)
(–)	ref	ref	ref	ref
Sleep time	-	-	-	-
≥ 6 h				
< 6 h				
Systolic blood pressure‡	1.02 (1.00-1.02)	1.03 (1.02-1.04)		
Fasting blood sugar‡			1.04 (1.03-1.06)	
Low-density lipoprotein‡		0.66 (0.38-1.14)		-

OR, odds ratio; CI, confidence interval.
†Based on unit 10, ‡Based on unit 5.

life-style related disease (OR 1.50, 95% CI 1.02-2.21).

Discussion

In our sample of male truck drivers in northern Japan, 13.2% had insomnia based on ICSD-3 and nearly half of the truck drivers had either one of the lifestyle-related diseases, including hypertension, diabetes mellitus, and dyslipidemia, according to their health insurance claims in 2020. Drivers with insomnia were approximately 2-fold more likely to have at least one lifestyle-related disease, hypertension, or dyslipidemia, although the association between insomnia and diabetes was marginally significant. To the best of our knowledge, this is the first study in Japan to show that truck drivers with insomnia may be at risk of developing lifestyle-related diseases, particularly hypertension, diabetes mellitus, and dyslipidemia. There was little association between occupational characteristics and lifestyle-related diseases.

A significant association between lifestyle-related diseases and insomnia was shown. Previous literature suggests that that insomnia could precede lifestyle-related diseases, and vice versa. For example, diabetes mellitus and poor BS control lead to insomnia since the accompanying symptoms such as nocturnal enuresis, peripheral neuropathy, restless legs syndrome, and sleep-disordered breathing cause sleep disturbance (Surani et al. 2015). In our study

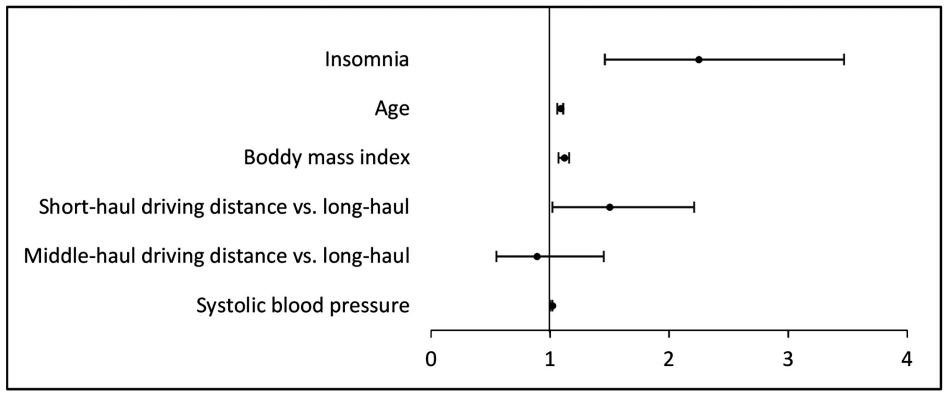

Fig. 2. Insomnia and Lifestyle-related diseases by multivariate logistic model with multiple imputation (n = 875).
Lifestyle-related diseases were significantly related with insomnia (OR 2.25, 95% CI 1.46-3.47), systolic blood pressure (OR 1.01, 95% CI 1.00-1.02), short-haul driving distance vs. long-haul (OR 1.50, 95% CI 1.02-2.21), body mass index (OR 1.12, 95% CI 1.07-1.16) and age (OR 1.09, 95% CI 1.06-1.11).

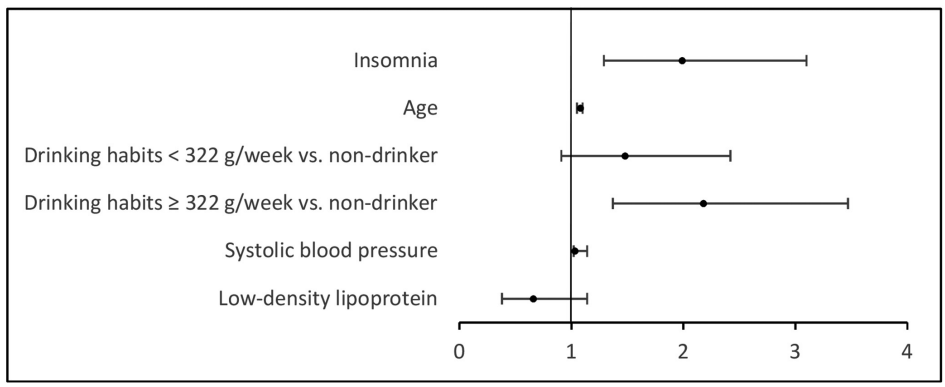

Fig. 3. Insomnia and Hypertension by multivariate logistic model with multiple imputation (n = 875).
Hypertension were significantly related with insomnia (OR 1.99, 95% CI 1.29-3.10), systolic blood pressure (OR 1.03, 95% CI 1.02-1.04), low-density lipoprotein (OR 0.66, 95% CI 0.38-1.14), drinking habits ≥ 322 g/wk vs. non-drinker (OR 2.18, 95% CI 1.37-3.47), and age (OR 1.08, 95% CI 1.05-1.10).

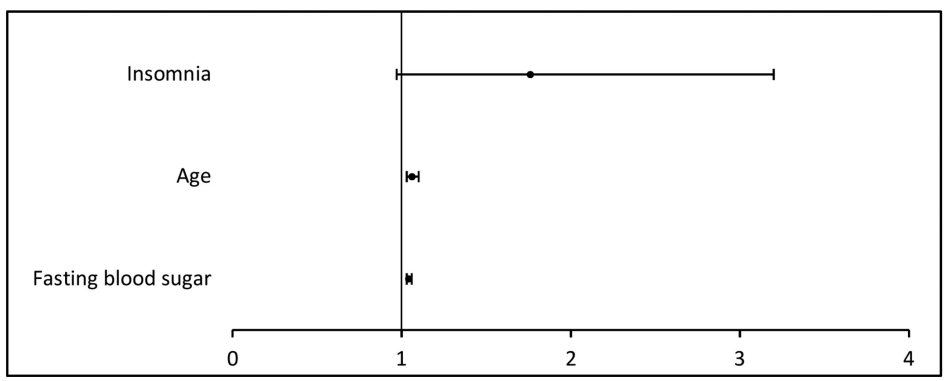

Fig. 4. Insomnia and Diabetes mellitus by multivariate logistic model with multiple imputation (n = 875).
Diabetes mellitus were significantly related with fasting blood sugar (OR 1.04, 95% CI 1.03-1.06), and age (OR 1.06, 95% CI 1.03-1.10).

sample, however, this scenario may be less likely as the majority of drivers were healthy workers with good BS control (median hemoglobin A1c, 5.4%). Therefore, the alternative scenario that sleep disturbance leads to diabetes mellitus by decreasing insulin sensitivity (Knutson et al. 2011), and increasing cortisol secretion (Spiegel et al. 1999), could explain our findings. This is supported by a meta-analysis based on cohort studies which showed that

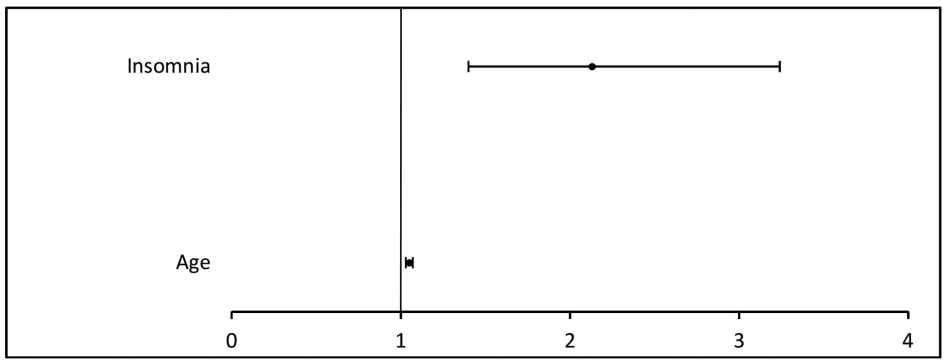

Fig. 5. Insomnia and Dyslipidemia by multivariate logistic model with multiple imputation (n = 875).
Dyslipidemia was significantly related with insomnia (OR 2.13, 95% CI 1.40-3.24), and age (OR 1.05, 95% CI 1.03-1.07).

subjects with insomnia symptoms at baseline are approximately twice as likely to develop diabetes mellitus compared with those without symptoms, and the risk of diabetes mellitus continues to increase with the length of follow-up (Cappuccio et al. 2010). Physiologically, insomnia is associated with reduced leptin and elevated ghrelin levels and obesity, which subsequently disturb glucose metabolism (Taheri et al. 2004). Additionally, labor characteristics of truck drivers, including sedentary position or psychological stress, may activate the sympathetic nervous system, which may modify the association between insomnia and diabetes.

We confirmed that drivers with insomnia were associated with an increased risk of hypertension. It is known that blood pressure levels measured in a health check-up venue may be prone to misclassification bias such as white-coat hypertension. In this regard, the strength of our study was that we used the ICD-10 code for hypertension embedded in health claim data. The association between hypertension and insomnia has remained controversial. In a short period of time, insomnia increases blood pressure levels via the sympathetic nervous system (Knutson et al. 2009). However, its long-term association has been inconsistent in various studies due to different methodologies, including the different definitions of insomnia and hypertension, various co-factors investigated, and the high possibility that insomnia occurs with other sleep disorders, such as apnea (Jarrin et al. 2018). In our study, we did not measure sleep apnea because the Ministry of Land, Infrastructure, Transport and Tourism recommends sleep apnea screening for all truck drivers and thus it is difficult to keep track of driver occupations once diagnosed. Nevertheless, we found that obesity and older age were significantly associated with hypertension. Since obesity and older age are high risk factors for sleep apnea (Adami et al. 2022), and one previous study in 1,309 Japanese commercial motor vehicle drivers aged 40-69 years also suggested that 23.9% had moderate to severe obstructive sleep apnea (Ueyama et al. 2018), our results might have been confounded.

Heavy alcohol consumption (≥ 322 g/week) was significantly associated with an increased risk of hypertension, which is consistent with previous findings (Roerecke et al. 2018; Jung et al. 2020). We also found that truck drivers with insomnia consumed significantly more alcohol than drivers without insomnia (274.7 ± 219.6 g/week vs. 233.3 ± 202.3 g/week), although statistical interaction between insomnia and hypertension with alcohol consumption was not significant in the multivariate model. This implies that drivers who have difficulty maintaining or initiating sleep consume alcohol as a nightcap. In Japan, taking alcohol to easily fall asleep is particularly common compared to other countries (19.4% in 10 countries vs. 30.3% in Japan) (Soldatos et al. 2005) and in shift workers, such as truck drivers (Johnson et al. 1998). Given that heavy alcohol consumption might be used to help induce sleep, and the fact that it also increases the risk of developing hypertension, the introduction of sleep hygiene measures among truck drivers could be a very useful substitute in maintaining their health status.

We also found an association between dyslipidemia and insomnia although two previous cross-sectional cohort studies in the United States (Vozoris 2016) and China (Zhan et al. 2014) showed no significant association between the two. Differences in study design, study subjects, and occupational characteristics may explain this discrepancy. In both studies, the study subjects were randomly selected from any occupation and were 20 years of age or older. In addition, blood samples were used to identify dyslipidemia, and insomnia was only asked about sleep status for the previous month. In other words, chronic insomnia, which can lead to dyslipidemia, was not taken into account. However, given that insomnia is associated with coronary artery disease (Maruyama et al. 2009) and that dyslipidemia is a well-known risk factor of cardiovascular disease (Pekkanen et al. 1990; St-Onge et al. 2016), our findings of a significant association between the two could be possible. Thus, future research such as the mechanism of how sleep disturbances could affect fat metabolism, and larger cohort studies investigating the impact of insomnia on the onset of dyslipidemia are highly warranted.

Surprisingly, this study showed little association between drivers' occupational characteristics and lifestyle-related diseases. This may be due to strict regulations for

motor vehicle drivers issued by the Labor Standards Inspection Offices and local transportation authorities. According to the "Standards for Improvement of Working Hours for Motor Vehicle Drivers", the maximum hours of operation is limited to 13 hours, at least a 30 minute-rest break when driving for > 4 hours, and no more than 9 hours of driving time per 2-day period (Labor Standards Inspection Offices and Local Transportation Authorities 1989). Because our study participants belonged to the Truck association the majority of companies have their drivers follow these rules. Under such strict regulation, driving hours, travel days, and driving distances might not affect the results. In addition, some occupational characteristics such as the sedentary posture of drivers might not have been measured. A previous meta-analysis of 10 cross-sectional studies revealed that the odds of metabolic syndrome increase by 73% with increased sedentary time (Edwardson et al. 2012). Given that the length of driving working time is equal to the time period of sedentary posture, the lack of physical activity contributes to the risk of lifestyle-related diseases and increases the risk of insomnia, leading to lifestyle-related diseases and eventually a malcycle (Hartescu and Morgan 2019). These explain the high prevalence of lifestyle-related diseases among truck drivers. In fact, the prevalence rates of hypertension, diabetes mellitus, and dyslipidemia in our sample were significantly higher than those of Japanese truck drivers in general: 29.7%, 11.7%, and 24.8%, vs. 19.3%, 5.7%, and 8.5%, respectively (Matsumoto et al. 2020). Sedentary posture, lack of physical activity, and other confounding factors should be individually measured to serve as basis for the development of active intervention methods.

Our study had some limitations. First, in addition to the small sample size, our study was biased due to the setting in one particular area of Japan, Akita prefecture, where the mortality of cerebrocardiovascular diseases is high (Nomura et al. 2017). Thus, the findings may not be generalizable to other areas. Second, because a significant number of drivers were excluded before the data were merged, selection bias may have existed. However, these drivers responded to a self-administered questionnaire and answered that they had agreed to provide data, but due to unavailable insurance data for 2020, they were excluded and were likely to be new entrants. Thus, inclusion of these drivers may have resulted in bias toward underestimation of lifestyle related diseases. Third, regarding the driving distance, which is an item in the self-administered questionnaire, a non-differential misclassification bias may have been present because some companies have very few employees, and one driver may be responsible for all types of driving distance. Fourth, the health insurance claims included both type 1 and 2 diabetes. According to a patient survey by the Ministry of Health, Labour and Welfare (2014), the prevalence of type 1 diabetes is approximately 0.09%, which should not significantly affect our findings. Fifth, this study demonstrated that insomnia is common among patients with lifestyle-related diseases. However, this may be explained by customary health practice. A study of the pharmacotherapy of insomnia using large-scale reimbursement data from Japan revealed that most sleeping pills are prescribed by general physicians but not necessarily by psychiatrists (Inada et al. 2021). This indicates that insomniacs may be more likely to visit general medicine where they were more likely to receive the diagnosis of lifestyle related diseases.

Thus, our results may need to be carefully interpreted in view of these limitations as well as the fact that our study design was of a cross-sectional nature hence causality cannot be assumed.

In conclusion, insomnia is significantly associated with an increased risk of lifestyle-related diseases, particularly hypertension, diabetes mellitus (marginally), and dyslipidemia among male truck drivers in Japan where the labor characteristics are regarded as a sedentary working style. Potential risk factors are older age and obesity for all lifestyle-related diseases and alcohol drinking for hypertension.

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Author Contributions

Kyoko Nomura and Takashi Miyachi designed this study. Tomoka Ando, Takashi Miyachi and Yuta Sugano analyzed the data and drafted the manuscript. Kazuo Mishima supervised manuscript structure from the viewpoint of mental health. All authors read, critically revised, and approved the final manuscript.

Conflict of Interest

The authors declare no conflict of interest.

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