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Rate of inappropriate energy and micronutrient intake among the Korean working population

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Abstract
Objective: Adequate energy and nutrient intakes are important for workers who spend at least one-third of their day working. We investigated differences in these intakes among Korean workers because few studies have reported on energy or nutrient intakes, related to working conditions (long working hours, shift work and non-standard work).
Design: Dietary intake was assessed using 1-d 24-h recall. Energy and nutrient intakes were evaluated using age- and sex-specific dietary reference intakes for Korean citizens. Occupational characteristics were obtained from self-reported Korean National Health and Nutritional Examination Survey (KNHANES) data (occupational classification, working hours, shift work and non-standard workers). An age, education and household income-adjusted logistic regression model was applied to investigate differences in inappropriate energy and nutrient intakes, by sex and occupation.
Setting: Cross-sectional study.
Participants: From KNHANES (2007–2016), 11 145 participants (5401 males; 5744 females) were included, finally.
Results: Males with long working hours had higher inappropriate carbohydrate, protein, water, vitamin B2 and phosphate intakes than those who worked ≤60 h/week. Long working hours among females were significantly associated with total energy and nutrient 'under-intake'. Male shift and non-standard workers had higher inappropriate protein, water, mineral and vitamin intakes. Multivariate logistic regression revealed that white- and male pink-collar workers had significantly increased risks of water and vitamins A, C, B_1 and niacin 'under-intake'.
Conclusions: We found different rates of inappropriate energy and micronutrient intakes according to working conditions. Younger workers with long hours and shift work schedules were vulnerable to inappropriate energy and nutrient intakes.

Keywords
Nutrition
Energy
Workers
Korean National Health and Nutritional Examination Survey

A safe and balanced food intake, a basic human right, can contribute to a sustained physical and mental health. Adequate energy and nutrient intakes are essential for preventing hunger and malnutrition and are also important for the maintenance of good health[1]. Dietary habituation is an important factor underlying energy and nutrient intakes (that can affect various health problems and nutritional deficiencies)[2]. Balanced eating by workers is fundamental to ensuring productivity, a healthy workforce, good working conditions and disease prevention[3,4].

The health status, represented by energy and nutrient intakes among workers who spend at least one-third of their day at work, is closely related to their working conditions. For example, working conditions with long working hours, workplace stress and shift work have been identified recently as risk factors for obesity[5,6]. A key aspect of obesity is an excessive energy intake. However, few studies have focused on energy or nutrient intakes among workers and their associated working conditions. The risk of obesity among workers is related to their working conditions, which ultimately influences their energy and nutrient intakes. Although previous research has reported that shift work schedules influence workers' eating habits[7], few studies have examined energy and

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nutrient intake statuses among workers. Adequate energy and nutrient statuses are key components of occupational safety and workplace health for both employers and workers; but these have rarely been investigated, even by occupational professionals.

The current study investigated the association between nutrient intake status among a working population and their working conditions. Understanding the link between nutrient intake and occupational characteristics while also considering sex and age differences will help improve occupational health and safety issues. First, this paper provides an overview of the nutrient intake statuses among Korean workers with sex and age stratification. Then, we demonstrated the association between working conditions (occupational classification, long working hours, shift work and non-standard work) and nutrient intake status with sex stratification.

Methods

Study population

The current study used the Korean National Health and Nutritional Examination Survey (KNHANES), which is a nationally representative and population-based survey conducted by the Korea Centres for Disease Control and Prevention (KCDC). We merged KNHANES data from 2007 to 2016, including food intake information. Figure 1 provides a schematic diagram depicting the study population. Of the 81 503 KNHANES participants from 2007 to 2016, we excluded those with non-paid work (*n 60 889*), without energy and nutrient intake survey results (*n 3222*), aged <20 or >65 years (*n 1732*) and those with any missing data (*n 4515*). Finally, a total of 11 145 participants (5401 males; 5744 females) were included.

Energy and nutrient intake variables

Energy and nutrient intake data were collected from the 1-d 24-h recall KNHANES survey. The nutritional survey included a face-to-face interview conducted in the participants' homes by trained dietitians 1 week after a basic health interview. The recall data included all foods and beverages consumed within a 24-h period on all weekdays except for national holidays[8–10].

Macronutrients were calculated as percentages of the total energy intake. The energy intake was calculated using standard conversion factors to convert grams to kilojoules (17 kJ/g for protein and carbohydrate and 37 kJ/g for fat). The age- and sex-specific estimated energy requirement (EER), estimated average requirement (EAR), acceptable macronutrient distribution ranges (AMDRs), recommended nutrient intake (RNI), adequate intake (AI) and tolerable upper intake level (UL) of the dietary reference intakes for Koreans (KDRIs) according to the Dietary Reference Intakes for Korean citizens[11–13] were used to estimate the energy and nutrient intake statuses (Supplementary Table 1).

The energy and nutrient intake statuses were categorised into the following four classes: total energy from primary sources (carbohydrate, fat and protein); water; vitamins (Vits) (A, C, B_1, B_2 and niacin) and minerals (Ca, phosphate, Na, K and Fe). Some of the energy and nutrient over-intake values are controversial. Therefore, the current study could only demonstrate an inadequate nutrient intake status based on the nutritional academic consensus for each nutrient. Thus, under-nutrition could only be estimated for protein, water, Vit C, Vit B_1, Vit B_2, niacin and K.

Total energy and nutrient 'under-intake' were defined as consumption ≤75 % of the EER (EAR for Ca, Fe, Vit A and Vit B_2). 'Over-intake' was defined as consumption ≥125 % of the EER (AMDR for fat intake). Both the under- and over-intake rates for total energy and nutrients were included in the KNHANES by the KCDC as indexes to monitor Korean citizens' nutritional-related health.

Carbohydrate and fat intakes were categorised into two classes (under and over) according to the percentage of total AMDR energy intake. Protein under-intake was defined as an amount below the EAR. Water under-intake was defined as fluid (ml) per day below the AI. Vit or mineral under-intake was defined as an intake below the EAR, whereas over-intake was defined as an intake greater than the UL.

Socioeconomic variables

For educational status and household income, we examined socioeconomic variables. The educational level was classified as less than high school, college or higher.

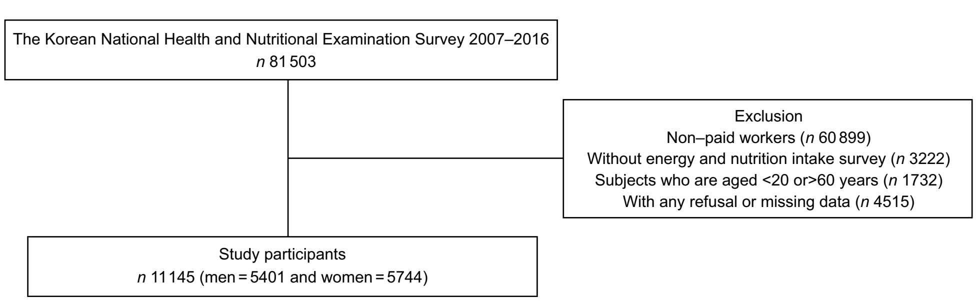

Fig. 1 Schematic diagram depicting study population

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Household income was categorised according to the total monthly household income (US dollars ($): <1400, <1900, <2500 and ≥2500).

Occupational characteristics

The occupational characteristics examined were occupational classification, long working hours, shift work and non-standard workers. As reported in a previous study[14], occupational classification was categorised into four groups based on the International Standard Classifications of Occupations by skill and duty levels as follows: white-collar workers (legislators, senior officials, managers, professionals, technicians and associated professionals); pink-collar workers (clerk, sales and customer service); green-collar workers (agriculture, fishery and forestry) and blue-collar workers (craft, plant and machine operators, assemblers and elementary workers). Long working hours were defined as >60 h/week. Shift work included night duty, evening duty, regular day and night shifts, 24-h shifts, separated shifts and irregular shift work schedules. Non-standard workers were employed temporarily or daily.

Statistical analysis

Energy and nutrient intakes according to sex, age and occupational characteristics were analysed using the χ^2 test. We also estimated the *P* values for trends to demonstrate the association between inappropriate energy and nutrient intakes and age. The risk of inappropriate energy and nutrient intakes was calculated using logistic regression analysis with both crude and fully adjusted models according to the occupational classification after sex stratification. The fully adjusted model was adjusted for age, education and household income. We calculated each of the inappropriate energy and nutrient status item as a count variable, and differences in the mean total number of inappropriate energy and nutrient statuses were analysed using Student's t-test according to sex and occupational characteristics.

Results

Participants

Table 1 shows the characteristics of the study participants. Overall, 48·5 % of the workers were male. The largest age group was 30–49 years (*n 5970*; 53·6 %). The largest proportion of the participants had a monthly household income greater than $2500 (35·8 %), followed by an income between $1900 and $2500 (33·8 %). Green-collar workers made up the least of the occupational classifications (*n 48*; 0·4 %). Among participants, 92·5 %, 82·1 % and 67·3 % had long working hours, shift work and non-standard working conditions, respectively.

Table 1 Baseline characteristics of study participants

	N	%
Gender		
Male	5401	48·5
Female	5744	51·5
Age (years)		
19–29	1931	17·3
30–49	5970	53·6
50–64	3244	29·1
Education		
High school	5022	45·1
College	1960	17·6
University and above	4163	37·3
Household monthly income ($)		
less than 1400	728	6·4
1400–1900	2672	23·9
1900–2500	3766	33·8
More than 2500	3979	35·8
Occupational classification		
White-collared	5487	49·2
Pink-collared	2003	18·0
Green-collared	48	0·4
Blue-collared	3604	32·4
Long working hours		
Yes	832	7·5
No	10 313	92·5
Shift work		
Yes	1990	17·9
No	9155	82·1
Non-standard workers		
Yes	3641	32·7
No	7504	67·3

Energy and nutrient intake statuses according to sex and age

The energy and nutrient intake statuses of the participants classified by sex and age are shown in Table 2. Table 3 shows the inappropriate energy and nutrient intake statuses for each nutrient according to sex and age. For both sexes, a significant difference was found in the prevalence of imbalanced daily energy, carbohydrate, fat, protein, water, Vit A, Vit C, Vit B_1, Vit B_2, phosphate, K and Fe intakes among the age groups. In males, a significant difference was also found in the prevalence of an inappropriate Ca intake.

Energy and nutrient intake statuses according to occupational characteristics

Tables 4 (males) and 5 (females) show inappropriate energy and nutrient intake statuses according to occupational characteristics. A significant difference was noted in inappropriate carbohydrate, protein, water, Vit C, Vit B_1, Vit B_2, niacin, phosphate and K intakes according to the male workers' occupational classifications. In females, a significant difference was found in the percentages of inappropriate total energy and nutrient, carbohydrate, protein, water, Vit B_1, Vit B_2, niacin, Ca and Fe intakes by occupational classification.

Males who worked >60 h/week showed higher inappropriate carbohydrate (74·9 % *v.* 72·7 %, $P = 0·0032$); protein (18·0 % *v.* 12·6 %, $P = 0·0002$); water (53·3 % *v.* 45·4 %, $P = 0·0003$); Vit B_2 (44·7 % *v.* 38·4 %, $P = 0·003$) and phosphate (6·9 % *v.* 4·4 %, $P = 0·0238$) intakes than those who worked ≤60 h/week. Also females who worked >60 h/week showed higher inappropriate carbohydrate

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Table 2 Energy and micronutrient intake status according to gender and age group

	Total		19–29		30–49		50–64	
Age (years)	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Male workers								
Number of participants	5401		772		3080		1549	
Daily energy intake								
Total energy (kJ)	10 771·3	4391·1	11 211	4996·5	11 032·8	4359·3	10 078·4	4029·2
Carbohydrate (%)	59·2	13·7	55·3	13·6	58·2	13·4	63·0	13·8
Fat (%)	20·2	8·4	24	8·9	20·9	8	16·7	7·7
Protein (g)	94·1	56·5	102·7	64·3	96·4	47·7	85·9	66·7
Water (ml)	1382·7	836·8	1384·6	828·5	1436·7	872·7	1282·1	757·5
Vitamins								
Vitamin A (μgRE)	942·1	1075·1	912·9	1056·9	956·5	1074·2	934·8	1080·3
Vitamin C (mg)	109·2	93·4	84·1	80·5	110·0	98·2	120·4	104·1
Vitamin B1 (mg)	2·2	1·2	2·2	1·4	2·2	1·1	2·1	1·1
Vitamin B2 (mg)	1·6	0·9	1·7	1·0	1·7	0·9	1·5	1·0
Niacin (mg)	21·7	13·6	22·7	14·1	22·2	11·5	20·5	16·9
Minerals								
Ca (mg)	597·7	356·8	564·8	353·3	605·4	353·3	600·6	364·0
P (mg)	1412·4	673·8	1405·2	682·9	1440·8	623·2	1365·3	756·9
Na (mg)	5796·5	4315·4	5687·7	4224·0	5956·5	3413·8	5563·8	5711·7
K (mg)	3637·5	1683·7	3346·2	1773·4	3685·6	1609·6	3699·6	1762·7
Fe (mg)	19·7	12·3	19·0	14·1	19·6	11·3	20·4	13·1
Female workers								
Number of participants	5744		1159		2890		1695	
Daily energy intake								
Total energy (kJ)	7580·2	3063·1	7806·9	3625·0	7623·7	2984·0	7354·6	2747·6
Carbohydrate (%)	64·2	12·3	58·6	12·7	63·4	11·5	69·4	11·2
Fat (%)	20·1	8·8	24·3	9·5	20·7	8·3	16·4	8·0
Protein (g)	64·9	33·4	68·7	41·4	65·9	32·7	60·8	27·8
Water (ml)	1031·4	528·9	1036·9	631·2	1043·9	571·2	1006·6	567·2
Vitamins								
Vitamin A (μgRE)	769·3	1054·3	674	1030·6	788·1	1105·7	802·6	973·7
Vitamin C (mg)	106·7	108·4	84·1	97·1	103·7	101·4	127·3	122·8
Vitamin B1 (mg)	1·6	0·9	1·5	1·0	1·6	0·9	1·6	0·8
Vitamin B2 (mg)	1·2	0·7	1·3	0·7	1·3	0·7	1·2	0·6
Niacin (mg)	15·3	7·9	15·6	9·1	15·7	7·9	14·7	7·1
Minerals								
Ca (mg)	470·2	281·3	428·8	258·5	477·9	289	485·5	280·6
P (mg)	1031·3	447·3	993·8	480·6	1044·3	434·4	1035·5	444·3
Na (mg)	3919·5	2716·4	3700·1	2627·1	4093·5	2801·7	3776·9	2610·4
K (mg)	2889·7	1520·1	2508·7	1276·8	2900·9	1491·8	3132·9	1662·9
Fe (mg)	14·9	8·8	12·9	8·3	15·0	8·7	16·0	9·1

(78·5 % *v.* 71·8 %, $P = 0{\cdot}0017$); protein (28·7 % *v.* 21·1 %, $P = 0{\cdot}0049$); water (62·0 % *v.* 53·4 %, $P = 0{\cdot}0093$); Vit B_1 (27·9 % *v.* 19·9 %, $P = 0{\cdot}0029$); Vit B_2 (48·5 % *v.* 41·5 %, $P = 0{\cdot}0364$) and niacin (39·2 % *v.* 31·2 %, $P = 0{\cdot}0089$) intakes.

Considering the work schedule, male shift workers were more likely to show inappropriate carbohydrate (74·5 % *v.* 72·7 %, $P = 0{\cdot}0065$); protein (16·4 % *v.* 12·5 %, $P = 0{\cdot}001$); water (55·4 % *v.* 45·2 %, $P < 0{\cdot}0001$); Vit C (50·2 % *v.* 45·1 %, $P = 0{\cdot}0036$); Vit B_1 (13·3 % *v.* 9·8 %, $P = 0{\cdot}0011$); Vit B_2 (42·6 % *v.* 38·3 %, $P = 0{\cdot}0131$); niacin (20·4 % *v.* 15·8 %, $P = 0{\cdot}0005$); Ca (67·3 % *v.* 62·2 %, $P = 0{\cdot}0048$); phosphate (6·8 % *v.* 4·1 %, $P = 0{\cdot}0023$) and K (58·9 % *v.* 52·5 %, $P = 0{\cdot}0002$) intakes than regular workers. For the female shift workers, inappropriate protein (24·3 % *v.* 20·8 %, $P = 0{\cdot}0165$); water (56·8 % *v.* 53·1 %, $P = 0{\cdot}0278$); Vit C (53·3 % *v.* 49·8 %, $P = 0{\cdot}0405$) and phosphate (15·7 % *v.* 11·8 %, $P = 0{\cdot}0012$) intakes were significantly higher than those of the regular workers.

Male non-standard workers showed higher inappropriate carbohydrate (74·7 % *v.* 72·1 %, $P = 0{\cdot}0349$); protein (15·6 % *v.* 12·2 %, $P = 0{\cdot}0009$); water (50·4 % *v.* 44·5 %, $P < 0{\cdot}0001$); Vit B_1 (13·0 % *v.* 9·4 %, $P < 0{\cdot}0001$); Vit B_2 (42·1 % *v.* 37·9 %, $P = 0{\cdot}0036$); niacin (18·7 % *v.* 15·8 %, $P = 0{\cdot}0108$) and K (56·5 % *v.* 52·5 %, $P = 0{\cdot}0076$) intakes than standard workers. Female non-standard workers showed significantly higher inappropriate carbohydrate (74·9 % *v.* 70·6 %, $P < 0{\cdot}0001$); protein (23·9 % *v.* 20·0 %, $P = 0{\cdot}0006$); water (56·3 % *v.* 52·3 %, $P = 0{\cdot}0039$); Vit A (63·1 % *v.* 60·4 %, $P = 0{\cdot}0115$); Vit B_1 (23·7 % *v.* 18·3 %, $P < 0{\cdot}0001$); Vit B_2 (44·5 % *v.* 40·2 %, $P = 0{\cdot}0015$); niacin (33·9 % *v.* 30·2 %, $P = 0{\cdot}004$) and phosphate (13·5 % *v.* 11·7 %, $P = 0{\cdot}0190$) intakes.

Table 3 The inappropriate energy and micronutrient intake of each energy and nutrient according to gender and age group

		Total		19–29		30–49		50–64			
Age (years)		*N*	%	*N*	%	*N*	%	*N*	%	*P* value	*P* for trend
Male workers											
Number of participants		5401		772		3080		1549			
Total energy and nutrition intake											
	Under	206	3·8	61	7·8	117	3·8	28	1·8	<0·0001	<0·0001
	Over	295	5·5	74	10·0	178	5·8	43	2·8	<0·0001	<0·0001
Energy intake by macronutrients											
Carbohydrate	Under	1862	34·5	348	45·3	1117	36·4	397	25·7	0·0009	0·0021
	Over	2081	38·5	202	26·3	1094	35·4	785	50·7	<0·0001	<0·0001
Fat	Under	1554	28·8	122	15·6	733	23·8	699	45·2	<0·0001	<0·0001
	Over	677	12·5	190	24·9	394	12·8	93	5·9	<0·0001	<0·0001
Protein	Under	712	13·2	112	14·4	352	11·4	248	16·0	0·0270	0·4020
Water intake											
	Under	2497	46·2	388	49·9	1467	47·5	642	41·5	<0·0001	0·0014
Vitamins											
Vitamin A	Under	2859	52·9	452	58·3	1616	52·3	791	51·1	0·0020	0·0035
	Over	150	2·8	20	2·6	87	2·8	43	2·8	0·7029	0·8746
Vitamin C	Under	2487	46·1	457	58·9	1385	44·9	645	41·6	<0·0001	<0·0001
Vitamin B1	Under	562	10·4	111	14·2	306	9·9	145	9·4	0·0011	0·0004
Vitamin B2	Under	2112	39·1	276	35·5	1120	36·3	716	46·2	<0·0001	<0·0001
Niacin	Under	900	16·7	147	18·9	469	15·1	284	18·3	0·6675	0·7952
Minerals											
Ca	Under	3404	63·0	538	69·6	1934	62·7	932	60·2	<0·0001	0·0006
	Over	19	0·4	1	0·1	5	0·2	13	0·8	0·0020	0·0053
P	Under	202	3·7	50	6·4	105	3·4	47	3·0	0·0003	0·0002
	Over	46	0·9	10	1·3	25	0·8	11	0·7	0·1698	0·0241
Na	Under	140	2·6	28	3·6	63	2·1	49	3·2	0·5325	0·8910
	Over	5102	94·5	719	93·2	2940	95·5	1443	93·2	0·2474	0·2833
K	Under	2898	53·7	488	62·9	1572	50·9	838	54·1	0·0043	0·0045
Fe	Under	353	6·5	106	13·6	202	6·5	45	2·9	<0·0001	<0·0001
	Over	188	3·5	35	4·6	103	3·3	50	3·2	0·0575	0·0742
Female workers		5744		1159		2890		1695			
Number of participants											
Total energy and nutrition intake											
	Under	629	10·9	227	19·6	327	11·3	75	4·4	<0·0001	<0·0001
	Over	250	4·4	79	6·8	134	4·6	37	2·2	<0·0001	<0·0001
Energy intake by macronutrients											
Carbohydrate	Under	1248	21·7	427	36·8	626	24·7	195	11·5	<0·0001	<0·0001
	Over	2896	50·4	369	31·8	1358	47·0	1169	68·9	<0·0001	<0·0001
Fat	Under	1807	31·5	196	17·0	772	26·7	839	49·5	<0·0001	<0·0001
	Over	811	14·1	304	26·2	394	13·6	113	6·7	<0·0001	<0·0001
Protein	Under	1227	21·4	333	28·7	508	17·6	386	22·8	0·0048	0·0045
Water intake											
	Under	3089	53·8	652	56·2	1602	55·4	835	49·3	<0·0001	0·0069
Vitamins											
Vitamin A	Under	3394	59·1	776	66·9	1681	58·2	937	55·3	<0·0001	<0·0001
	Over	135	2·4	19	1·6	63	2·2	53	3·1	0·1036	0·1363
Vitamin C	Under	2893	50·4	729	62·8	1451	50·2	713	42·1	<0·0001	<0·0001
Vitamin B1	Under	1162	20·2	288	24·8	532	18·4	342	20·2	0·0109	0·0033
Vitamin B2	Under	2398	41·8	471	40·6	1135	39·3	792	46·7	0·0002	<0·0001
Niacin	Under	1810	31·5	391	33·7	852	29·5	567	33·5	0·7613	0·6626
Minerals											
Ca	Under	3922	68·2	862	74·3	1851	64·0	1210	71·4	0·4782	0·6764
	Over	6	0·1	0	0·0	5	0·2	1	0·1	0·8098	0·9031
P	Under	708	12·3	190	16·4	328	11·4	190	11·2	0·0001	0·0002
	Over	9	0·2	4	0·3	2	0·1	3	0·2	0·3458	0·6219
Na	Under	569	9·9	146	12·6	244	8·4	179	10·6	0·0578	0·0445
	Over	4647	80·9	900	77·7	2420	83·7	1327	78·3	0·1016	0·0618
K	Under	4317	75·2	967	83·4	2172	75·1	1178	69·5	<0·0001	<0·0001
Fe	Under	1686	29·4	576	49·7	1012	35·0	98	5·8	<0·0001	<0·0001
	Over	74	1·3	11	1·0	38	1·3	25	1·5	0·4445	0·4698

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Table 4 The inappropriate energy and micronutrient intake of each nutrient according to occupational characteristics in male workers (*n* 5401)

		Occupational classification									Long working hours					Shift work					Non-standard workers				
		White	*N* (%)	Pink	*N* (%)	Green	*N* (%)	Blue	*N* (%)	*P* value	No	*N* (%)	Yes	*N* (%)	*P* value	No	*N* (%)	Yes	*N* (%)	*P* value	No	*N* (%)	Yes	*N* (%)	*P* value
Number of participants		2648		594		38		2121			4806		595			4405		996			3827		1574		
Total energy and nutrition intake																									
	Under	84	3·2	33	5·6	2	5·3	87	4·1	0·1579	173	3·6	33	5·6	0·0201	151	3·4	55	5·5	0·0020	132	3·5	74	4·7	0·0288
	Over	125	5·7	44	7·4	1	2·6	98	4·6	0·0705	264	5·5	31	5·2	0·8601	244	5·5	51	5·1	0·7047	209	5·5	86	5·5	0·9134
Energy intake by macronutrients																									
Carbohydrate	Under	986	37·2	235	39·6	8	21·1	633	29·8	0·0901	1688	35·1	174	29·2	0·3987	1551	35·2	311	31·2	0·5845	1320	34·5	542	34·4	0·2328
	Over	909	34·3	207	34·9	22	57·9	943	44·5	<0·0001	1809	37·6	272	45·7	0·0099	1650	37·5	431	43·3	0·0148	1446	37·8	635	40·3	0·0343
Fat	Under	618	23·3	135	22·7	19	50·0	782	36·9	<0·0001	1339	27·9	215	36·1	0·0002	1252	28·4	302	30·3	0·1394	1054	27·5	500	31·8	0·0019
	Over	383	14·5	105	17·7	1	2·6	188	8·9	0·0001	619	12·9	58	9·8	0·2081	543	12·3	134	13·5	0·1913	484	12·7	193	12·3	0·7061
Protein	Under	268	10·1	83	13·9	10	26·3	351	16·6	<0·0001	605	12·6	107	18·0	0·0002	549	12·5	163	16·4	0·001	467	12·2	245	15·6	0·0009
Water intake	Under	1093	41·3	310	52·2	21	55·3	1073	50·6	<0·0001	2180	45·4	317	53·3	0·0003	1945	45·2	552	55·4	<0·0001	1703	44·5	794	50·4	<0·0001
Vitamins																									
Vitamin A	Under	1357	51·3	340	57·2	25	65·8	1137	53·6	0·2423	2532	52·7	327	55·0	0·3718	2305	52·3	554	55·6	0·0771	2008	52·5	851	54·1	0·2733
	Over	80	3·0	24	4·0	1	2·6	45	2·1	0·0761	137	2·9	13	2·2	0·4406	126	2·9	24	2·4	0·6439	106	2·8	44	2·8	0·8031
Vitamin C	Under	1126	42·5	327	55·1	15	39·5	1019	48·0	0·0007	2211	46·0	276	46·4	0·8602	1987	45·1	500	50·2	0·0036	1763	46·1	724	46·0	0·9626
Vitamin B1	Under	236	8·9	82	13·8	6	15·8	238	11·2	0·0158	489	10·2	73	12·3	0·1146	430	9·8	132	13·3	0·0011	358	9·4	204	13·0	<0·0001
Vitamin B2	Under	961	36·3	220	37	20	52·6	911	42·9	<0·0001	1846	38·4	266	44·7	0·0030	1688	38·3	424	42·6	0·0131	1449	37·9	663	42·1	0·0036
Niacin	Under	346	13·1	113	19·0	9	23·7	432	20·4	<0·0001	792	16·5	108	18·2	0·3020	697	15·8	203	20·4	0·0005	606	15·8	294	18·7	0·0108
Minerals																									
Ca	Under	1642	62·0	389	65·5	26	68·4	1347	63·5	0·2717	3029	63·0	375	63·0	0·9502	2738	62·2	666	66·9	0·0049	2398	62·7	1006	63·9	0·3745
	Over	8	0·3	0	0·0	0	0·0	11	0·5	0·1531	18	0·4	1	0·2	0·4210	15	0·3	4	0·4	0·5935	13	0·3	6	0·4	0·7608
P	Under	70	2·6	36	6·1	1	2·6	95	4·5	0·0023	166	3·5	36	6·1	0·0016	143	3·3	59	5·9	<0·0001	140	3·7	62	3·9	0·6016
	Over	25	0·9	3	0·5	0	0·0	18	0·9	0·8030	41	0·9	5	0·8	0·9794	37	0·8	9	0·9	0·7846	28	0·7	18	1·1	0·1318
Na	Under	53	2·0	21	3·5	0	0·0	66	3·1	0·1154	117	2·4	23	3·9	0·2669	105	2·9	35	3·5	0·2003	83	2·2	57	3·6	0·0241
	Over	2518	95·1	566	93·6	34	89·5	1994	94·0	0·9058	4549	94·7	553	92·9	0·6577	4171	94·7	931	93·5	0·8420	3630	94·9	1472	93·5	0·8803
K	Under	1356	51·2	345	58·1	22	57·9	1175	55·4	0·0065	2580	53·7	318	53·5	0·9127	2311	52·5	587	58·9	0·0002	2009	52·5	889	56·5	0·0076
Fe	Under	145	5·5	58	9·8	3	7·9	147	6·9	0·0848	302	6·3	51	8·6	0·0468	265	6·0	88	8·8	0·0014	228	5·9	125	7·9	0·0072
	Over	97	3·7	23	3·8	2	5·3	66	3·1	0·3387	178	3·7	10	1·7	0·0139	159	3·6	29	2·9	0·3514	133	3·5	55	3·5	0·8649

Table 5 The inappropriate energy and micronutrient intake of each nutrient according to occupational characteristics in female workers (*n* 5744)

		Occupational classification									Long working hours					Shift work					Non-standard workers					
		White (*N*)	%	Pink (*N*)	%	Green (*N*)	%	Blue (*N*)	%	*P* value	No (*N*)	%	Yes (*N*)		*P* value	No (*N*)	%	Yes (*N*)	%	*P* value	No (*N*)	%	Yes (*N*)	%	*P* value
Number of participants		2839		1409		10		1486			5507		237			4750		994			3677		2067		
Total energy and nutrition intake																									
	Under	344	12·1	145	10·3	0	0·0	140	9·4	0·0028	596	10·8	33	13·9	0·1505	500	10·5	129	13·0	0·0226	408	11·1	221	10·7	0·5740
	Over	152	5·4	53	3·8	0	0·0	45	3·0	0·0002	242	4·4	8	3·4	0·5137	205	4·3	45	4·5	0·6377	169	4·6	81	3·9	0·2129
Energy intake by macronutrients																									
Carbohydrate	Under	713	25·1	302	21·4	0	0·0	233	15·7	0·5976	1207	21·9	41	17·3	0·8836	1008	21·2	240	24·1	0·0241	816	22·2	432	20·9	0·2215
	Over	1201	42·3	755	53·6	9	90·0	931	62·7	<0·0001	2751	49·9	145	61·2	0·0042	2398	50·5	498	50·1	0·3041	1780	48·4	1116	54·0	<0·0001
Fat	Under	642	22·6	515	36·6	8	80·0	642	43·2	<0·0001	1699	30·9	108	45·6	<0·0001	1487	31·3	320	32·2	0·3335	1079	29·3	728	35·2	<0·0001
	Over	509	17·9	176	12·5	0	0·0	126	8·5	<0·0001	793	14·4	18	7·6	0·0578	657	13·8	154	15·5	0·1128	549	14·9	262	12·7	0·2502
Protein	Under	545	19·2	323	22·9	4	40·0	355	23·9	0·0003	1159	21·1	68	28·7	0·0049	986	20·8	241	24·3	0·0165	734	20·0	493	23·9	0·0006
Water intake	Under	1464	51·6	761	54	7	70·0	857	57·7	0·0001	2942	53·4	147	62·0	0·0093	2523	53·1	566	56·8	0·0278	1925	52·3	1164	56·3	0·0039
Vitamins																									
Vitamin A	Under	1674	58·9	857	60·8	7	70·0	856	57·6	0·7618	3251	59·0	143	60·3	0·4342	2778	58·5	616	62·0	0·0548	2149	58·4	1245	60·2	0·0757
	Over	53	1·9	32	2·3	1	10·0	49	3·3	0·0043	125	2·3	14	4·2	0·0375	115	2·4	20	2·0	0·6791	74	2·0	61	2·9	0·0104
Vitamin C	Under	1440	50·7	723	51·3	4	40·0	726	48·9	0·2321	2779	50·5	114	48·1	0·4765	2363	49·8	530	53·3	0·0405	1864	50·7	1029	49·8	0·5074
Vitamin B1	Under	530	18·7	306	21·7	5	50·0	321	21·6	0·0194	1096	19·9	66	27·9	0·0029	949	19·9	213	21·4	0·3009	672	18·3	490	23·7	<0·0001
Vitamin B2	Under	1062	37·4	625	44·4	8	80·0	703	47·3	<0·0001	2283	41·5	115	48·5	0·0364	1961	41·3	437	43·9	0·1193	1478	40·2	920	44·5	0·0015
Niacin	Under	810	28·5	472	33·5	6	60·0	522	35·1	<0·0001	1717	31·2	93	39·2	0·0089	1478	31·1	332	33·4	0·1586	1110	30·2	700	33·9	0·0040
Minerals																									
Ca	Under	1884	66·4	965	68·5	8	80·0	1065	71·7	0·0003	3754	68·2	168	70·9	0·3390	3218	67·8	704	70·8	0·0580	2484	67·6	1438	69·6	0·1073
	Over	3	0·1	1	0·1	0	0·0	2	0·1	0·6425	5	0·1	1	0·4	0·0979	5	0·1	1	0·1	0·9599	3	0·1	3	0·2	0·4246
P	Under	326	11·5	184	13·1	2	20·0	196	13·2	0·1024	677	12·3	31	13·1	0·7254	553	11·6	155	15·6	0·0006	430	11·7	278	13·5	0·0487
Na	Over	4	0·1	3	0·2	0	0·0	2	0·1	0·9711	9	0·2	0	0·0	0·5352	8	0·2	1	0·1	0·6548	3	0·1	6	0·3	0·0507
	Under	261	9·2	152	10·8	0	0·0	156	10·5	0·4561	546	9·9	23	9·7	0·5754	452	9·5	117	11·8	0·4042	354	9·6	215	10·4	0·5809
K	Over	2328	82·0	1113	79·0	10	100·0	1196	80·5	0·7490	4458	80·9	189	79·8	0·4653	3868	81·4	779	78·4	0·2970	2986	81·2	1661	80·4	0·8449
	Under	2142	75·5	1071	76·0	9	90·0	1095	73·7	0·2128	4138	75·1	179	75·5	0·8927	3560	74·9	757	76·2	0·4223	2750	74·8	1567	75·8	0·3900
Fe	Under	958	33·7	416	29·5	3	30·0	309	20·8	<0·0001	1621	29·4	65	27·4	0·5307	1368	28·8	318	32·0	0·0434	1099	29·9	587	28·4	0·2425
	Over	31	1·1	18	1·3	1	10·0	24	1·6	0·3928	70	1·3	4	1·7	0·6151	61	1·3	13	1·3	0·8323	46	1·3	28	1·4	0·8053

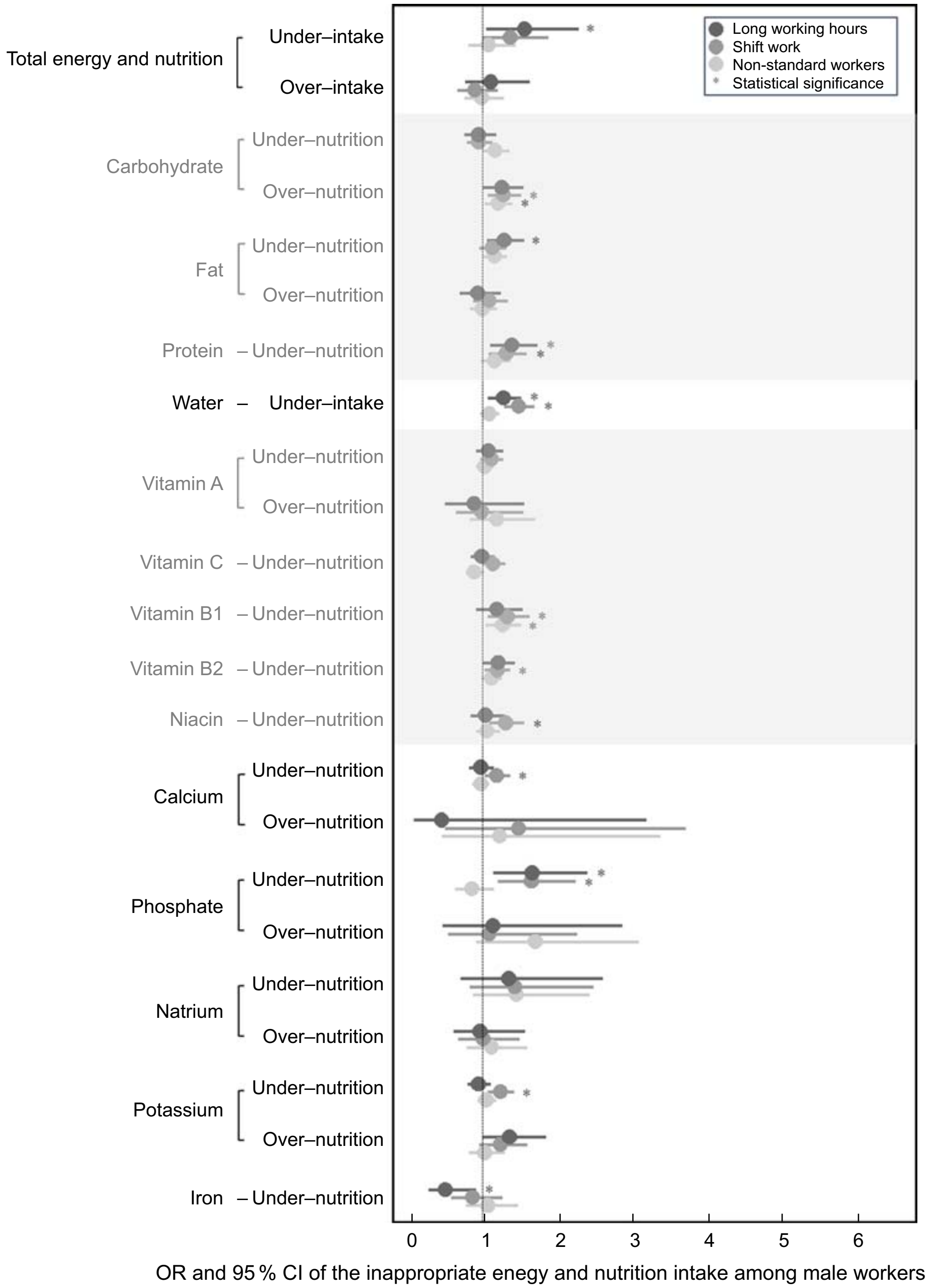

Fig. 2 Risk for inappropriate energy and nutrition intake according to occupational characteristics in male workers (OR and 95 % CIs) Results are from 'Yes' to long working hours, shift work and non-standard work compared with 'No', respectively

Risk of inappropriate energy and micronutrients intakes according to occupational characteristics

Supplementary Tables 2 and 3 and Figs. 2 and 3 show the risk analysis for inappropriate energy and nutrient intakes according to the occupational classification or characteristics based on the multivariate logistic regression model for each sex. When each occupational group was compared with those of the white-collar workers, male pink-collar workers had a significantly higher risk of water, Vit A, Vit C, Vit B_1 and niacin under-intake. Green-collar workers had a higher risk of protein under-intake, whereas male blue-collar workers had a higher risk of niacin under-intake. In contrast, the risk of inappropriate intake by female pink- and green-collar workers was not significantly different from that of the white-collar workers. Only female blue-collar workers had a higher risk of carbohydrate and Vit A over-intake.

As shown in Fig. 2, males with long working hours had a higher risk of total energy and nutrient, fat, protein, water and phosphate under-intake than those who did not work

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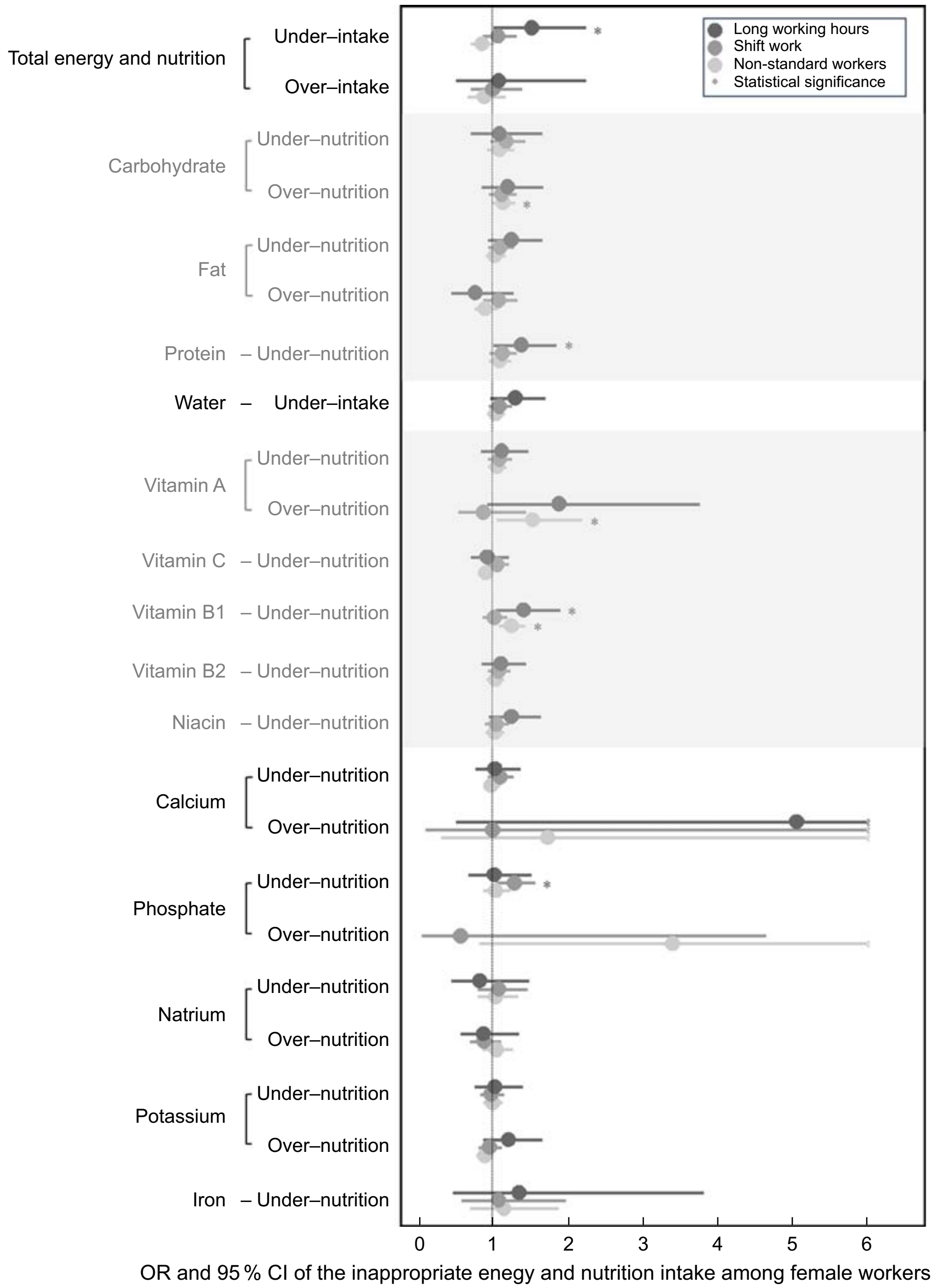

Fig. 3 Risk for inappropriate energy and nutrition intake according to occupational characteristics in female workers (OR and 95 % CIs) Results are from 'Yes' to long working hours, shift work and non-standard work compared with 'No', respectively

long hours. In contrast, long working hours were associated with a lower risk of Fe under-intake. Long working hours were significantly associated with under-intake of total energy and nutrients, protein and Vit B_1 in females (Fig. 3). Male shift workers had a higher risk of carbohydrate over-intake and protein, water, Vit B_1, Vit B_2, niacin, Ca, phosphate and K under-intake than day workers. Female shift workers only had a significantly higher risk of phosphate under-intake compared with that of day workers. Non-standard male workers were at a higher risk of carbohydrate over-intake and Vit B_1 under-intake than standard workers. On the other hand, female non-standard workers had a higher risk of carbohydrate and Vit A over-intake than standard workers.

Discussion

The current study demonstrated differences in energy and nutrient intakes among Korean workers according to age, sex and occupational characteristics.

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We found that younger workers of both sexes had an increased prevalence of inappropriate energy and nutrient intake statuses (total energy and nutrient intakes and the intakes of each macronutrient, Vit A, Vit C, Vit B_1, Ca, phosphate, K and Fe). This finding is contrary to those of previous studies, which suggested that elderly populations may have a greater risk of inappropriate energy and nutritional statuses due to medical, lifestyle, psychological and social factors[15]. This result may be explained by the fact that younger workers may experience greater workloads and stress than older workers[16]. As a result, younger workers may skip meals or have insufficient time to eat at work. Therefore, in the working population, younger workers may be at risk of inappropriate energy and nutrient intakes.

We found sex differences between workers with inappropriate energy and nutrient intakes. This result can be explained in part by not only behavioural and sociocultural factors but also by chromosomal factors. Energy intake habituation in women is linked to menstrual cycle-related hormones[17]. Hypothalamic regulators, which impact both energy homeostasis and the reproductive axis, are closely related to sex-specific energy and nutrient intakes[18]. Therefore, the findings of the current study further support sex differences in energy and nutrient intakes.

The current study also demonstrated that occupational characteristics were related to inappropriate energy and nutrient intakes. First, we can infer that long working hours may result in inappropriate energy and nutrient intakes. Males and females working long hours had inadequate daily energy intakes, with a tendency to consume less fat and protein than recommended. This finding is contrary to those of a previous study, which found that these workers had a tendency to overeat and had high BMIs[19]. In that study, stress was suggested as the main contributing factor for the high BMI in Japanese male workers with long hours, with the additional contribution from later dinner time and irregular intake. Another study also found that long working hours influenced negative emotions and led to binge eating behaviour[20]. One explanation for our finding may be that long working hours might have contributed to irregular food intake and meal skipping, resulting in poor daily energy intake. Inadequate energy intake is known to increase the risk of psychiatric symptoms, such as dizziness, dyspepsia and depression[21–23]. Thus, interventions should be designed to improve energy intake for workers with long hours.

Second, shift work schedules could be a risk factor for inappropriate energy and nutrient intakes. Shift workers may have altered dietary patterns and food choices[7,24], and increased consumption of unhealthy foods related to chronic diseases has been reported[25]. Our study demonstrated that male shift workers had excessive carbohydrate intake. This finding was consistent with those of previous studies, which showed that shift workers' eating habits included less regular meal patterns with multiple snacks and higher energy intake at night[7]. Moreover, our study further supported the expended scope of the risk of unhealthy food intake among shift workers, especially for Vits and minerals. Male shift workers reported under-intake of Vit B_1, Vit B_2, niacin, phosphate and K. These findings have important implications for developing nutritional interventions. This is because niacin is the most widely used medication for raising HDL-cholesterol levels. Indeed, niacin has been shown to increase HDL-cholesterol by 16–25 %[26,27], which leads to a decreased CVD risk. Shift work is a well-known risk factor of CVD[28,29]. Phosphate deficiency was also noted in males working long hours and female shift workers. Phosphate plays a key role in energy production and is a component of ATP, DNA and RNA[30].

One unanticipated finding was that non-standard workers were a vulnerable population for inappropriate energy and nutrient intakes. Non-standard work cannot be an occupational hazard, because this work is a type of contract employment. Surprisingly, vulnerable points of the food intake status was found in non-standard workers; significantly increased risks for carbohydrate over-intake and Vit B_1 under-intake were found for both male and female workers. Further research should focus on determining the process underlying the inappropriate energy and nutrient intakes among non-standard workers.

Another important finding of the current study was the risk of inadequate water intake among the working population. An increased risk of inadequate water intake was observed among male pink-collar workers and those with long hours or shift work. Providing employees with safe drinking water is the responsibility of every employer, as specified by the Occupational Safety and Health Administration regulations. However, previous studies have focused on the importance of hydration for outdoor workers but have neglected its impact on service or sales businesses. Inadequate water supply reduces the plasma volume and influences the circulatory system, which controls blood flow to the skin and working muscles. This phenomenon leads to muscle fatigue and an increased body temperature. Thus, subclinical dehydration affects physical performance and cognitive function and may precede workplace injuries[31]. In addition, since long working hours and shift work are known cardiovascular[26,29] and musculoskeletal risk factors[30], water intake interventions should be considered.

The current study has several strengths and limitations. First, the study revealed associations between inappropriate energy and nutrient intakes and occupational characteristics. This topic has received relatively little attention, and very few studies have focused on the working population. In addition, the current study also investigated Vit and mineral intakes. Second, statistical significance was achieved mainly due to the large sample size of nationally representative data. Limitations include the use of 24-h recall for investigating food intake. This method has several

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weaknesses because it relies on memory, and food intake may be underestimated due to recall bias, the interviewee's capacity could have affected the precision of the report. Individual variation can occur according to the day when the survey was administered, and excessive or deficient nutrients might have been under-/over-estimated using the 1-d 24-h recall survey[32]. However, the 24-h recall design has several benefits because the burden on the interviewee is relatively small, and the survey is easy to complete with low research expenses. Moreover, the KNHANES data contain information on micronutrients (Vits, minerals, fatty acids, etc.) and are suitable for estimating the average intakes of the group. Another limitation of the study is the ecological model design on which the current study was based. Therefore, these findings must be interpreted with caution before application to individuals. Lastly, although the cross-sectional nature of the current study makes establishing the direction of influence difficult, the energy and nutrient intakes are unlikely to lead to different occupational characteristics.

Conclusion

The current study assessed inappropriate energy and nutrient intake statuses according to age, sex and occupational characteristics and revealed some important findings. Younger workers with long hours and shift work schedule were at risk of having inappropriate energy and nutrient intakes. In addition, non-standard workers were a vulnerable population for dietary intake, and water intake was inappropriate among pink-collar workers and workers with long hours or shift work. Workers spend at least one-third of their day in the workplace; thus, further research into eating habits in the workplace is an essential step in investigating inappropriate energy and nutrient intakes among the working population.

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Supplementary material

For supplementary material accompanying this paper visit https://doi.org/10.1017/S1368980019004075.

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