

# Association of Dietary Behaviors with Poor Sleep Quality and Increased Risk of Obstructive Sleep Apnea in Korean Military Service Members

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**Purpose:** Sleep quality among military service members is important for enhancing their capabilities and preventing psychiatric problems. We aimed to explore the association of dietary behaviors with poor sleep quality and increased risk of obstructive sleep apnea (OSA) in military men on active duty.

**Patients and Methods:** A large-scale multi-site cross-sectional survey was conducted in five units of the Republic of Korea's army. Poor sleep quality and increased risk of OSA were defined using the Pittsburgh sleep quality index (PSQI) and Berlin Questionnaire, respectively. Information on dietary behaviors, including the frequency of skipping breakfast, eating snacks, consuming a night meal, and overeating, were collected.

**Results:** From August 2021 to September 2021, 4389 male respondents, mean age (20.8 ± 1.3 years), completed the survey; 2579 (58.8%) were assessed as having poor sleep quality, and 614 (14.0%) increased risk of OSA. After adjusting for lifestyle and occupational covariates, skipping breakfast 1–2 times weekly was associated with an increased likelihood of experiencing poor sleep quality, compared with not skipping breakfast (odds ratio: 1.23 [95% CI 1.02–1.47]). Eating night meals 5–6 times weekly was also associated with poor sleep quality (odds ratio: 5.54 [95% CI 2.49–14.18]). In addition, skipping breakfast daily (odds ratio: 2.28 [95% CI 1.27–4.03]) and eating night meals daily (odds ratio: 2.30 [95% CI 1.21–4.22]) were related to an increased risk of OSA.

**Conclusion:** Dietary behaviors appear to be related to poor sleep quality and a high risk of OSA. To improve sleep quality, dietary factors could be considered when promoting health programs for military personnel in further research.

**Keywords:** sleep, dietary behavior, insomnia, obstructive sleep apnea, military

## Introduction

Sleep is an integral component of well-being that critically influences physical and mental abilities. In the military, sufficient sleep is important to ensure the adequate performance of individual members, promote mission success in each military unit, and even enhance national security.<sup>1,2</sup> Enlisted personnel tend to have worse sleep quality than officers because they live in more crowded sleeping quarters.<sup>3,4</sup> In addition, the number of patients visiting the United States (US) military medical facilities for insomnia and obstructive sleep apnea (OSA) showed a tendency to increase over time.<sup>4,5</sup>

Furthermore, there have been multiple studies of military personnel reporting the association of sleep disorders with post-traumatic stress disorder,<sup>6</sup> depression,<sup>7</sup> and anxiety.<sup>8–12</sup>

Epidemiological studies assessing sleep conditions have been conducted in the military across several countries. A Korean military health survey reported that 8.8–10.1% of the total respondents had moderate-to-severe sleep difficulty.<sup>13,14</sup> Similarly, 8.1% of the study population in a single Korean military hospital had a high risk of OSA.<sup>15</sup> Contrarily, a study involving US military personnel indicated that the incidence rates of insomnia and OSA were 2.7% and 3.3%, respectively.<sup>5</sup> Additionally, the prevalence of subthreshold insomnia in multiple US army units ranged from 29.6 to 54.3%.<sup>16</sup>

In our previous study, most military personnel with insomnia had indigestion and were likely to eat night meals and snacks more frequently. After prescribing herbal medicine that could enhance digestive function, their insomnia improved.<sup>17</sup> In a previous study regarding sleep disorders and associated medical comorbidities, pain syndrome was found to increase the risk of insomnia.<sup>6</sup> Since it has been observed that many young male patients in the Korean army with insomnia also have indigestion symptoms linked to dietary habits, a large-scale cross-sectional study exploring the association between dietary behaviors and sleep was planned. The association between sleep and dietary behaviors has been examined in various populations, including factory workers<sup>18</sup> and white-collar workers,<sup>19</sup> but there is limited related research among military personnel. Military service members share similar sleep and nutritional conditions, and the effect of personal dietary behaviors on sleep can be clearly assessed after adjusting for related lifestyle and occupational factors.

This study, therefore, aimed to explore dietary factors, including skipping breakfast, overeating, snacking, and eating night meals, associated with poor sleep quality and high risk of OSA among military service members. Potential covariates of demographic and occupational factors in the military were also comprehensively evaluated.

## Materials and Methods

### Study Population

This cross-sectional survey was conducted among five units of the Republic of Korea's army from August to September 2021. A link to the online survey was provided to members on active duty, and the responses were collected by five Korean medical doctors. Eligible service members participated in the study using their cellular phones. All participants provided informed consent and voluntarily participated in the study. The collected data were managed anonymously, and access was restricted so that only the specific researchers could access the personal information of the enrolled participants. The protocol and survey questionnaire were approved by the institutional review board of the Armed Forces Medical Command (AFMC-202107-HR-054-02). This study was conducted in accordance with the Declaration of Helsinki.

This study included enlisted service members on active duty aged  $\geq 19$  years who had completed their basic military training course. They comprised only enlisted service members in the following ranks: private, private first-class, corporal, and sergeant.

### Definition of Poor Sleep Quality and High Risk of OSA

Poor sleep quality was defined by the global score of the Pittsburgh sleep quality index (PSQI), which is calculated by summing the seven component scores, including subjective quality, latency, duration, efficiency, disturbance of sleep, use of sleep medication, and daytime dysfunction.<sup>20</sup> Two studies validated the Korean version of the PSQI and reported cut-off values of  $> 8$  and  $> 5$ , respectively.<sup>21,22</sup> Herein, we defined poor sleep quality as a global PSQI score  $> 5$ . An additional analysis was also carried out with the higher PSQI threshold of  $> 9$ , based on a previous PSQI study on military personnel.<sup>23</sup> High risk of OSA was defined using the Berlin Questionnaire,<sup>24</sup> which comprises three categories: snoring and witnessed apnea, daytime sleepiness or tiredness, and presence of hypertension or obesity. A high risk of OSA was reported when two or three categories were present.<sup>25</sup>

### Study Variables

Dietary behavior information was collected using the dietary habit survey questionnaire,<sup>26</sup> which included 25 items used to evaluate dietary habits, and we selected four items based on previous research. The frequencies of skipping breakfast, overeating, snacking, and eating night meals were included in the analysis.<sup>17–19</sup>

Data on demographic, lifestyle, and occupational factors were also collected to be analyzed as covariates. Participants' age, educational level, height, and weight were recorded. Lifestyle factors included perceived stress level, smoking history, frequency of drinking, aerobic exercise per week, and coffee consumption. Occupational factors within the military included rank (private, private first class, corporal, or sergeant), position (combat arms, driver, military chef, administration), and the frequency of night shifts.

## Statistical Analyses

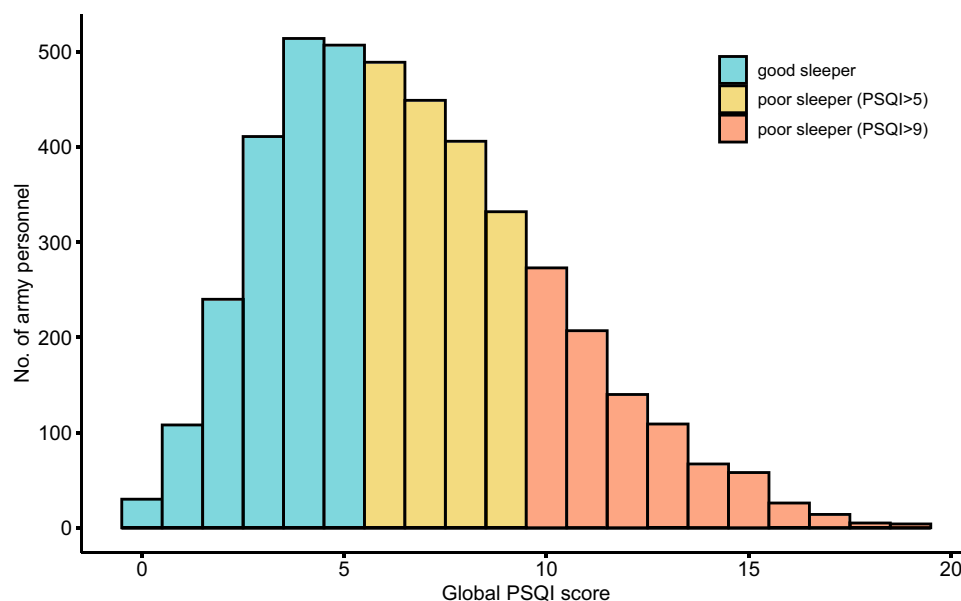
Categorical variables were presented as frequencies (%), while continuous variables were presented as means (standard deviation). To compare the frequencies or means between the two groups (PSQI  $\leq 5$  and PSQI  $> 5$ ) and (high risk or low risk of sleep apnea), the chi-square test or independent *t*-test was performed, respectively. Multivariable logistic regression analysis was used to explore the association between poor sleep quality and dietary behaviors; and between high risk of OSA and dietary behaviors. Demographic, lifestyle, and occupational factors were also included in the model as covariates. Unadjusted (univariate), and adjusted (multivariable) odds ratios, 95% confidence interval (CI), and *p*-value are presented. For statistical significance,  $p < 0.05$ . All analyses were performed using R version 4.1.3.<sup>27,28</sup>

## Results

### Study Flow and Characteristics of the Participants

In total, 4869 responses were collected through the online survey. After removing 35 duplicate responses and 139 responses from participants who did not meet the inclusion criteria (aged under 19 years or members not on active duty), 4695 responses from eligible participants remained. Of the 4695 eligible respondents, 4389 completed the entire survey without missing any sections.

The participants were men with a mean age of  $20.8 \pm 1.3$  years. A PSQI global cutoff score  $>5$  indicated poor sleep quality in 2579 (58.8%) respondents. The distribution of the PSQI global score in all participants is presented in Figure 1. Furthermore, 614 (14.0%) respondents were assessed as having a high risk of OSA according to the Berlin questionnaire. The participants' characteristics are presented in Table 1. According to the existence of poor sleep quality and high risk of OSA, the characteristics of the participants showed differences in various demographic, lifestyle, occupational, and dietary factors.



**Figure 1** Distribution of global Pittsburgh sleep quality index (PSQI) scores.

**Table 1** Characteristics of Military Service Members

		Sleep Quality			OSA		
		PSQI ≤ 5 (n=1810)	PSQI > 5 (n=2579)	p value	Low Risk (n=3775)	High Risk (n=614)	p value
<b>Demographics and Lifestyle</b>							
Age, years	Mean (SD)	20.7 (1.2)	20.9 (1.3)	<0.001	20.8 (1.3)	20.9 (1.3)	0.022
Education	≤ High school	1704 (94.1)	2422 (93.9)	0.800	3548 (94.0)	578 (94.1)	0.957
	College or higher	106 (5.9)	157 (6.1)		227 (6.0)	36 (5.9)	
BMI, kg/m <sup>2</sup>	Mean (SD)	23.8 (2.9)	23.9 (2.8)	0.524	23.5 (2.5)	25.8 (3.7)	<0.001
Smoking	Never	1035 (57.2)	1288 (49.9)	<0.001	2014 (53.4)	309 (50.3)	0.363
	Past smoker	96 (5.3)	165 (6.4)		224 (5.9)	37 (6.0)	
	Current smoker	679 (37.5)	1126 (43.7)		1537 (40.7)	268 (43.6)	
Drinking	< 1/month	468 (25.9)	571 (22.1)	<0.001	900 (23.8)	139 (22.6)	0.010
	< 1/week	516 (28.5)	698 (27.1)		1039 (27.5)	175 (28.5)	
	1–2/week	609 (33.6)	888 (34.4)		1311 (34.7)	186 (30.3)	
	3–7/week	217 (12.0)	422 (16.4)		525 (13.9)	114 (18.6)	
Exercise	< 1/week	265 (14.6)	444 (17.2)	0.128	576 (15.3)	133 (21.7)	<0.001
	1–2/week	436 (24.1)	622 (24.1)		897 (23.8)	161 (26.2)	
	3–4/week	533 (29.4)	717 (27.8)		1098 (29.1)	152 (24.8)	
	≥ 5/week	576 (31.8)	796 (30.9)		1204 (31.9)	168 (27.4)	
Stress	Very low	268 (14.8)	98 (3.8)	<0.001	353 (9.4)	13 (2.1)	<0.001
	Low	377 (20.8)	233 (9.0)		577 (15.3)	33 (5.4)	
	Moderate	870 (48.1)	1100 (42.7)		1721 (45.6)	249 (40.6)	
	High	221 (12.2)	848 (32.9)		845 (22.4)	224 (36.5)	
	Very high	74 (4.1)	300 (11.6)		279 (7.4)	95 (15.5)	
Coffee	< 1/week	734 (40.6)	912 (35.4)	<0.001	1454 (38.5)	192 (31.3)	<0.001
	1–2/week	440 (24.3)	551 (21.4)		855 (22.6)	136 (22.1)	
	3–6/week	291 (16.1)	439 (17.0)		631 (16.7)	99 (16.1)	
	1/day	202 (11.2)	350 (13.6)		461 (12.2)	91 (14.8)	
	2/day	98 (5.4)	214 (8.3)		251 (6.6)	61 (9.9)	
	≥ 3/day	45 (2.5)	113 (4.4)		123 (3.3)	35 (5.7)	

(Continued)

Table I (Continued).

		Sleep Quality			OSA		
		PSQI $\leq$ 5 (n=1810)	PSQI > 5 (n=2579)	p value	Low Risk (n=3775)	High Risk (n=614)	p value
<b>Occupational factors</b>							
Rank	Private	192 (10.6)	131 (5.1)	<0.001	291 (7.7)	32 (5.2)	0.095
	Private first class	807 (44.6)	1048 (40.6)		1594 (42.2)	261 (42.5)	
	Corporal	583 (32.2)	1068 (41.4)		1403 (37.2)	248 (40.4)	
	Sergeant	228 (12.6)	332 (12.9)		487 (12.9)	73 (11.9)	
Position	Combat arms	1246 (68.8)	1725 (66.9)	<0.001	2531 (67.0)	440 (71.7)	0.001
	Driver	250 (13.8)	255 (9.9)		436 (11.5)	69 (11.2)	
	Military chef	48 (2.7)	107 (4.1)		124 (3.3)	31 (5.0)	
	Administration	266 (14.7)	492 (19.1)		684 (18.1)	74 (12.1)	
Night shift with off-duty <sup>a</sup>	None	1071 (59.2)	1391 (53.9)	<0.001	2090 (55.4)	372 (60.6)	0.003
	<1/month	113 (6.2)	123 (4.8)		205 (5.4)	31 (5.0)	
	2/month	167 (9.2)	205 (7.9)		329 (8.7)	43 (7.0)	
	3/month	177 (9.8)	253 (9.8)		360 (9.5)	70 (11.4)	
	4/month	122 (6.7)	177 (6.9)		277 (7.3)	22 (3.6)	
	$\geq$ 5/month	160 (8.8)	430 (16.7)		514 (13.6)	76 (12.4)	
Night shift without off-duty <sup>a</sup>	None	1090 (60.2)	1333 (51.7)	<0.001	2093 (55.4)	330 (53.7)	0.832
	<1/month	59 (3.3)	95 (3.7)		129 (3.4)	25 (4.1)	
	2/month	80 (4.4)	108 (4.2)		159 (4.2)	29 (4.7)	
	3/month	80 (4.4)	99 (3.8)		157 (4.2)	22 (3.6)	
	4/month	95 (5.2)	123 (4.8)		189 (5.0)	29 (4.7)	
	$\geq$ 5/month	406 (22.4)	821 (31.8)		1048 (27.8)	179 (29.2)	
<b>Dietary behaviors</b>							
Skipping breakfast	None	1392 (76.9)	1658 (64.3)	<0.001	2655 (70.3)	395 (64.3)	<0.001
	1-2/week	269 (14.9)	536 (20.8)		683 (18.1)	122 (19.9)	
	3-4/ week	94 (5.2)	242 (9.4)		283 (7.5)	53 (8.6)	
	5-6/week	29 (1.6)	91 (3.5)		100 (2.6)	20 (3.3)	
	7/week	26 (1.4)	52 (2.0)		54 (1.4)	24 (3.9)	

(Continued)

Table 1 (Continued).

		Sleep Quality			OSA		
		PSQI ≤ 5 (n=1810)	PSQI > 5 (n=2579)	p value	Low Risk (n=3775)	High Risk (n=614)	p value
Overeating	None	1104 (61.0)	1312 (50.9)	<0.001	2143 (56.8)	273 (44.5)	<0.001
	1–2/week	549 (30.3)	922 (35.8)		1260 (33.4)	211 (34.4)	
	3–4/ week	108 (6.0)	259 (10.0)		278 (7.4)	89 (14.5)	
	5–6/week	20 (1.1)	42 (1.6)		43 (1.1)	19 (3.1)	
	7/week	29 (1.6)	44 (1.7)		51 (1.4)	22 (3.6)	
Snacking	None	218 (12.0)	200 (7.8)	<0.001	374 (9.9)	44 (7.2)	0.023
	1–2/week	484 (26.7)	681 (26.4)		1000 (26.5)	165 (26.9)	
	3–4/week	408 (22.5)	569 (22.1)		861 (22.8)	116 (18.9)	
	5–6/week	122 (6.7)	190 (7.4)		268 (7.1)	44 (7.2)	
	1/day	314 (17.3)	470 (18.2)		664 (17.6)	120 (19.5)	
	2/day	190 (10.5)	310 (12.0)		415 (11.0)	85 (13.8)	
	≥ 3/day	74 (4.1)	159 (6.2)		193 (5.1)	40 (6.5)	
Night meals	None	1101 (60.8)	1307 (50.7)	<0.001	2105 (55.8)	303 (49.3)	0.001
	1–3/month	275 (15.2)	419 (16.2)		599 (15.9)	95 (15.5)	
	1–2/week	325 (18.0)	551 (21.4)		744 (19.7)	132 (21.5)	
	3–4/ week	78 (4.3)	205 (7.9)		230 (6.1)	53 (8.6)	
	5–6/week	7 (0.4)	45 (1.7)		41 (1.1)	11 (1.8)	
	7/week	24 (1.3)	52 (2.0)		56 (1.5)	20 (3.3)	
<b>Sleep characteristics</b>							
Subjective sleep duration	Mean (SD)	7.7 (0.7)	6.6 (1.1)	<0.001	7.1 (1.1)	7.0 (1.0)	0.001
PSQI global score	Mean (SD)	3.5 (1.3)	8.9 (2.6)	<0.001	6.5 (3.3)	8.3 (3.4)	<0.001

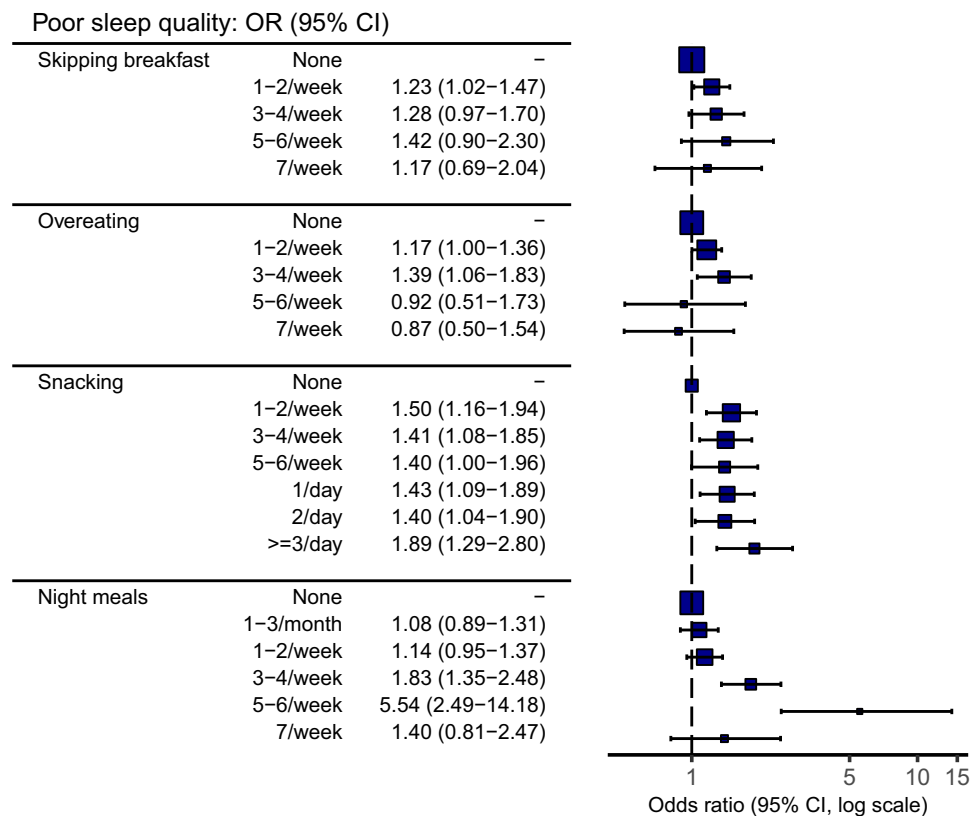
Note: <sup>a</sup>Going off duty right after night shift.

Abbreviations: OSA, obstructive sleep apnea; BMI, body mass index; PSQI, Pittsburgh sleep quality index; SD, standard deviation.

## Poor Sleep Quality and Associated Factors

### Dietary Behaviors

The adjusted odds ratios of dietary behaviors in the presence of poor sleep quality are presented in Figure 2 and Table 2. In the multivariable logistic regression, skipping breakfast 1–2 times a week was related to a greater likelihood of poor sleep quality than not skipping breakfast (odds ratio: 1.23 [95% confidence interval (CI): 1.02–1.47],  $p < 0.001$ ). The results of the univariable and multivariable logistic regression showed that the odds ratios tended to increase as the frequency of skipping breakfast increased to 5–6 times a week. Additionally, overeating 1–2 times or 3–4 times per week was associated with poor sleepers. Those who frequently ate snacks showed a significantly greater likelihood of experiencing poor sleep quality than those who did not ( $\chi^2 = 13.6$ ,  $df = 6$ ,  $p = 0.035$ ). Eating night meals 3–4 times or 5–6 times per week significantly increased the likelihood of poor sleep quality. However, eating night meals daily did not appear to be associated with an increased likelihood of poor sleep quality. The overall effect of night meals on poor



**Figure 2** Forest plot of the odds ratios of dietary behaviors on poor sleep quality. Adjusted odds ratios and 95% confidence intervals (CI) were calculated in the multivariable logistic model using demographic, lifestyle, and occupational factors as the covariates. The size of the square represents the number of participants in each item.

sleep quality was significant ( $X^2 = 22.3$ ,  $df = 5$ ,  $p < 0.001$ ). Also, additional results of dietary behaviors for poor sleep quality (defined as a higher PSQI threshold  $> 9$ ), are shown in [Table 3](#). A similar tendency was observed between the dietary behaviors and poor sleep quality in both models for the two PSQI thresholds. The effects of skipping breakfast, overeating, and eating night meals on poor sleep quality seem distinctive when applying a higher PSQI threshold.

### Other Lifestyle and Occupational Factors

The overall results of the multivariable logistic regression are presented in [Tables S1](#) and [S2](#). The severity of stress was highly associated with an increased likelihood of poor sleeping ( $X^2 = 375.1$ ,  $df = 4$ ,  $p < 0.001$ ). Additionally, coffee consumption more than twice daily had distinct effects on poor sleep quality when compared with drinking coffee less than once a week (twice daily: odds ratio 1.35 [95% CI 1.02-1.81],  $\geq$ three times daily: odds ratio 1.51 [95% CI: 1.02-2.27]). Among occupational factors, servicemen with military chef positions showed a greater likelihood of poor sleep quality than men in combat arms' positions. In contrast, servicemen who were drivers showed a lower likelihood of being poor sleepers. Regardless of being off-duty after a night shift, frequent night shifts for more than five times a month were associated with poor sleep quality, compared with no night shifts.

## High Risk of OSA and Associated Factors

### Dietary Behaviors

The adjusted odds ratios of dietary behaviors in the presence of a high risk of OSA are presented in [Figure 3](#) and [Table 4](#). The results of the univariate and multivariable logistic regression showed that skipping breakfast every day led to a greater likelihood of being at high risk of OSA, compared with not skipping breakfast. Moreover, overeating 3-4 times a week was associated with a high risk of OSA. Frequent overeating was associated with a greater likelihood of being at high risk of OSA, as shown in the univariate logistic regression. However, this tendency decreased after adjusting for demographic factors, mainly body mass index (BMI). Snacking did not appear to be associated with a high risk of OSA

**Table 2** Multivariable Logistic Regression of Dietary Behaviors for Poor Sleep Quality (PSQI > 5)

		PSQI ≤ 5 (n=1810)	PSQI > 5 (n=2579)	Unadjusted Odds Ratio	Adjusted Odds Ratio <sup>a</sup>	Overall Effect
Skipping breakfast	None	1392 (76.9)	1658 (64.3)	–	–	$\chi^2 = 8.0$ df = 4 p = 0.092
	1–2/week	269 (14.9)	536 (20.8)	1.67 (1.42–1.97, p<0.001)	1.23 (1.02–1.47, p=0.029)	
	3–4/week	94 (5.2)	242 (9.4)	2.16 (1.69–2.78, p<0.001)	1.28 (0.97–1.70, p=0.082)	
	5–6/week	29 (1.6)	91 (3.5)	2.63 (1.75–4.09, p<0.001)	1.42 (0.90–2.30, p=0.141)	
	7/week	26 (1.4)	52 (2.0)	1.68 (1.05–2.74, p=0.033)	1.17 (0.69–2.04, p=0.564)	
Overeating	None	1104 (61.0)	1312 (50.9)	–	–	$\chi^2 = 8.6$ df = 4 p = 0.073
	1–2/week	549 (30.3)	922 (35.8)	1.41 (1.24–1.61, p<0.001)	1.17 (1.00–1.36, p=0.048)	
	3–4/week	108 (6.0)	259 (10.0)	2.02 (1.59–2.57, p<0.001)	1.39 (1.06–1.83, p=0.019)	
	5–6/week	20 (1.1)	42 (1.6)	1.77 (1.05–3.09, p=0.038)	0.92 (0.51–1.73, p=0.796)	
	7/week	29 (1.6)	44 (1.7)	1.28 (0.80–2.07, p=0.314)	0.87 (0.50–1.54, p=0.634)	
Snacking	None	218 (12.0)	200 (7.8)	–	–	$\chi^2 = 13.6$ df = 6 p = 0.035
	1–2/week	484 (26.7)	681 (26.4)	1.53 (1.23–1.92, p<0.001)	1.50 (1.16–1.94, p=0.002)	
	3–4/week	408 (22.5)	569 (22.1)	1.52 (1.21–1.91, p<0.001)	1.41 (1.08–1.85, p=0.011)	
	5–6/week	122 (6.7)	190 (7.4)	1.70 (1.26–2.29, p<0.001)	1.40 (1.00–1.96, p=0.052)	
	1/day	314 (17.3)	470 (18.2)	1.63 (1.28–2.07, p<0.001)	1.43 (1.09–1.89, p=0.010)	
	2/day	190 (10.5)	310 (12.0)	1.78 (1.37–2.32, p<0.001)	1.40 (1.04–1.90, p=0.029)	
	≥ 3/day	74 (4.1)	159 (6.2)	2.34 (1.68–3.29, p<0.001)	1.89 (1.29–2.80, p=0.001)	
Night meals	None	1101 (60.8)	1307 (50.7)	–	–	$\chi^2 = 22.3$ df = 5 p < 0.001
	1–3/month	275 (15.2)	419 (16.2)	1.28 (1.08–1.53, p=0.004)	1.08 (0.89–1.31, p=0.436)	
	1–2/week	325 (18.0)	551 (21.4)	1.43 (1.22–1.68, p<0.001)	1.14 (0.95–1.37, p=0.158)	
	3–4/week	78 (4.3)	205 (7.9)	2.21 (1.69–2.92, p<0.001)	1.83 (1.35–2.48, p<0.001)	
	5–6/week	7 (0.4)	45 (1.7)	5.42 (2.60–13.19, p<0.001)	5.54 (2.49–14.18, p<0.001)	
	7/week	24 (1.3)	52 (2.0)	1.83 (1.13–3.03, p=0.016)	1.40 (0.81–2.47, p=0.241)	

**Notes:** Odds ratio (OR), 95% confidence intervals, and p-value are presented. <sup>a</sup>Multivariable logistic regression: Dietary behaviors + Demographics and Lifestyle factors + Occupational factors (Detailed results of all variables are presented in [Table S1](#)).

after adjusting for covariates. In contrast, eating night meals was associated with a high risk of OSA. The overall effect of night meals on high risk of OSA was statistically significant ( $\chi^2 = 13.2$ , df = 5,  $p = 0.021$ ).

### Other Lifestyle and Occupational Factors

The overall results of the multivariable logistic regression are presented in [Table S3](#). Exercising for more than 3–4 times a week was negatively correlated with a high risk of OSA. Furthermore, stress and drinking coffee more than three times a day had distinct effects on high risk of OSA. Among occupational factors, servicemen in administrative positions showed a lower likelihood of being at high risk of OSA than men in the combat arms division. The frequency of night shifts did not seem to be associated with high-risk OSA.

## Discussion

In this cross-sectional study conducted among military service members in Korea, we explored poor sleep quality, high risk of OSA, and associated dietary factors. Among various dietary behaviors, a higher frequency of snacking and



**Table 3** Multivariable Logistic Regression of Dietary Behaviors for Poor Sleep Quality (PSQI > 9)

		PSQI ≤ 9 (n=3486)	PSQI > 9 (n=903)	Unadjusted Odds Ratio	Adjusted Odds Ratio <sup>a</sup>	Overall Effect
Skipping breakfast	None	2533 (72.7)	517 (57.3)	–	–	$\chi^2 = 20.9$ $df = 4$ $p < 0.001$
	1–2/week	596 (17.1)	209 (23.1)	1.72 (1.43–2.06, $p < 0.001$ )	1.31 (1.06–1.62, $p = 0.011$ )	
	3–4/week	229 (6.6)	107 (11.8)	2.29 (1.78–2.93, $p < 0.001$ )	1.36 (1.01–1.82, $p = 0.041$ )	
	5–6/week	68 (2.0)	52 (5.8)	3.75 (2.57–5.43, $p < 0.001$ )	2.25 (1.45–3.45, $p < 0.001$ )	
	7/week	60 (1.7)	18 (2.0)	1.47 (0.84–2.46, $p = 0.158$ )	0.72 (0.38–1.33, $p = 0.309$ )	
Overeating	None	2000 (57.4)	416 (46.1)	–	–	$\chi^2 = 11.2$ $df = 4$ $p = 0.025$
	1–2/week	1144 (32.8)	327 (36.2)	1.37 (1.17–1.62, $p < 0.001$ )	1.15 (0.95–1.38, $p = 0.154$ )	
	3–4/week	243 (7.0)	124 (13.7)	2.45 (1.92–3.12, $p < 0.001$ )	1.62 (1.21–2.17, $p = 0.001$ )	
	5–6/week	44 (1.3)	18 (2.0)	1.97 (1.10–3.38, $p = 0.018$ )	1.03 (0.53–1.93, $p = 0.932$ )	
	7/week	55 (1.6)	18 (2.0)	1.57 (0.89–2.65, $p = 0.102$ )	1.00 (0.51–1.87, $p = 0.991$ )	
Snacking	None	353 (10.1)	65 (7.2)	–	–	$\chi^2 = 10.6$ $df = 6$ $p = 0.1$
	1–2/week	923 (26.5)	242 (26.8)	1.42 (1.06–1.93, $p = 0.021$ )	1.50 (1.07–2.13, $p = 0.019$ )	
	3–4/week	783 (22.5)	194 (21.5)	1.35 (0.99–1.84, $p = 0.059$ )	1.36 (0.96–1.95, $p = 0.091$ )	
	5–6/week	238 (6.8)	74 (8.2)	1.69 (1.17–2.45, $p = 0.006$ )	1.46 (0.95–2.24, $p = 0.083$ )	
	1/day	638 (18.3)	146 (16.2)	1.24 (0.91–1.72, $p = 0.183$ )	1.14 (0.79–1.66, $p = 0.484$ )	
	2/day	384 (11.0)	116 (12.8)	1.64 (1.18–2.31, $p = 0.004$ )	1.34 (0.91–1.98, $p = 0.140$ )	
	≥ 3/day	167 (4.8)	66 (7.3)	2.15 (1.45–3.17, $p < 0.001$ )	1.71 (1.08–2.68, $p = 0.021$ )	
Night meals	None	1986 (57.0)	422 (46.7)	–	–	$\chi^2 = 22.2$ $df = 5$ $p < 0.001$
	1–3/month	559 (16.0)	135 (15.0)	1.14 (0.91–1.41, $p = 0.244$ )	0.92 (0.72–1.18, $p = 0.522$ )	
	1–2/week	653 (18.7)	223 (24.7)	1.61 (1.33–1.93, $p < 0.001$ )	1.39 (1.12–1.73, $p = 0.003$ )	
	3–4/week	200 (5.7)	83 (9.2)	1.95 (1.48–2.57, $p < 0.001$ )	1.71 (1.24–2.36, $p = 0.001$ )	
	5–6/week	34 (1.0)	18 (2.0)	2.49 (1.37–4.40, $p = 0.002$ )	2.08 (1.03–4.09, $p = 0.037$ )	
	7/week	54 (1.5)	22 (2.4)	1.92 (1.13–3.14, $p = 0.012$ )	1.24 (0.67–2.25, $p = 0.483$ )	

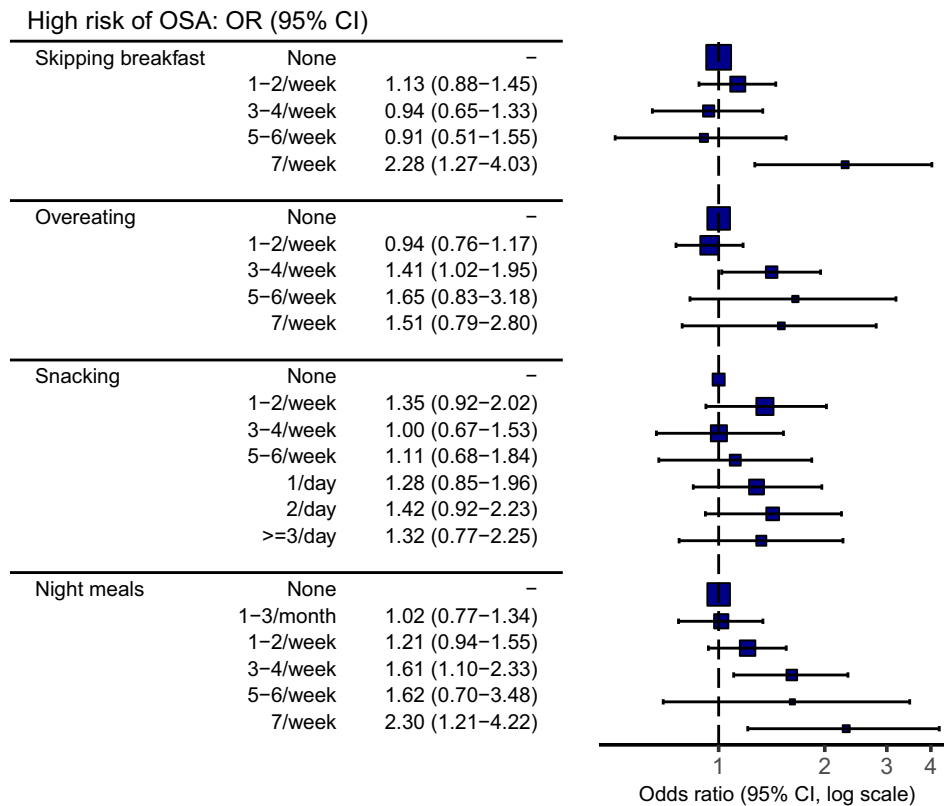
**Notes:** Odds ratio (OR), 95% confidence intervals, and p-value are presented. <sup>a</sup>Multivariable logistic regression: Dietary behaviors + Demographics and Lifestyle factors + Occupational factors (Detailed results of all variables are presented in [Table S2](#)).

frequent and irregular eating of night meals were associated with poor sleep quality. In addition, a higher frequency of skipping breakfast, overeating, and having night meals seemed to be associated with a high risk of OSA.

## Dietary Behaviors and Poor Sleep Quality

### Night Meals

The time of eating has a major impact on circadian rhythms, and eating at night may shift and even disrupt such rhythms.<sup>29,30</sup> In a previous study, higher caloric intake during dinner and late in the night was associated with longer sleep latency and lower sleep efficiency in women.<sup>31</sup> In another study, late dinner was positively associated with poor sleep quality when compared to having an early dinner.<sup>32</sup> In our study, we found that the higher frequency of eating night meals was associated with an increased tendency for poor sleep quality. In particular, the odds ratio dramatically increased when eating night meals 5–6 times per week. Interestingly, the effect of eating night meals on poor sleep quality was partially eliminated by eating night meals daily, 7 times per week. Frequent and irregular eating of night meals appears to be negatively associated with sleep quality. In addition to circadian rhythm disruptions, having to digest



**Figure 3** Forest plot of the odds ratios of dietary behaviors on high risk of obstructive sleep apnea (OSA). Adjusted odds ratios and 95% confidence interval (CI) were calculated in the multivariable logistic model using demographic, lifestyle, and occupational factors as the covariates. The size of the square represents the number of participants in each item.

food or indigestion that might arise from eating night meals may negatively affect sleep quality.<sup>31,33</sup> At the same time, the possibility of reverse causation also exists, in that participants with poor sleep quality may tend to eat night meals. Meanwhile, the concept of “night eating syndrome” has been proposed as a stress-related eating disorder, which is mainly characterized by night eating patterns and sleep disturbance.<sup>34,35</sup> The pathophysiology of “night eating syndrome” describes the stress-induced decrease in the nocturnal secretion of melatonin and leptin as causing both eating night meals and insomnia.<sup>36</sup> Eating night meals and poor sleep quality seems to be highly associated. The possible mechanism related to the association requires further research.<sup>37</sup>

### Snacks/Overeating

In an epidemiological study of Japanese men aged 20–59 years, snacking habits were related to insufficient hours of sleep.<sup>18</sup> Herein, the calculated odds ratio of poor sleep quality increased as the frequency of snacking and overeating increased. Furthermore, overeating 1–4 times a week also increased the likelihood of poor sleep. Snacking and overeating habits may also cause indigestion.<sup>38</sup> Furthermore, consuming high-fat diets has been reported to worsen sleep/wake fragmentation in mice models.<sup>39</sup> In addition, stress-induced eating in individuals with poor sleep quality may increase snacking habits, with a preference for eating energy-dense items.<sup>40</sup> Further, sleeping for a short duration is known to affect appetite regulatory hormones, reducing leptin and elevating ghrelin,<sup>41</sup> which may induce overeating. A recent randomized trial reported that interventions to increase sleep duration significantly decreased energy intake in overweight patients.<sup>42</sup> Poor sleep quality and habits of snacking and overeating seem to have a reciprocal relationship.

### Skipping Breakfast

Previous studies on the relationship between skipping breakfast and sleep patterns commonly reported that late sleepers typically tend to skip breakfast and a late bedtime is associated with the tendency to skip breakfast.<sup>43,44</sup> This could be

**Table 4** Multivariable Logistic Regression of Dietary Behaviors for High Risk of OSA

		Low-Risk OSA (n=3775)	High-Risk OSA (n=614)	Unadjusted Odds Ratio	Adjusted Odds Ratio <sup>a</sup>	Overall Effect
Skipping breakfast	None	2655 (70.3)	395 (64.3)	-	-	$\chi^2 = 9.3$ df = 4 p = 0.054
	1–2/week	683 (18.1)	122 (19.9)	1.20 (0.96–1.49, p=0.103)	1.13 (0.88–1.45, p=0.329)	
	3–4/week	283 (7.5)	53 (8.6)	1.26 (0.91–1.71, p=0.148)	0.94 (0.65–1.33, p=0.722)	
	5–6/week	100 (2.6)	20 (3.3)	1.34 (0.80–2.15, p=0.238)	0.91 (0.51–1.55, p=0.734)	
	7/week	54 (1.4)	24 (3.9)	2.99 (1.80–4.83, p<0.001)	2.28 (1.27–4.03, p=0.005)	
Overeating	None	2143 (56.8)	273 (44.5)	-	-	$\chi^2 = 9.1$ df = 4 p = 0.06
	1–2/week	1260 (33.4)	211 (34.4)	1.31 (1.08–1.59, p=0.005)	0.94 (0.76–1.17, p=0.599)	
	3–4/week	278 (7.4)	89 (14.5)	2.51 (1.91–3.28, p<0.001)	1.41 (1.02–1.95, p=0.036)	
	5–6/week	43 (1.1)	19 (3.1)	3.47 (1.95–5.95, p<0.001)	1.65 (0.83–3.18, p=0.143)	
	7/week	51 (1.4)	22 (3.6)	3.39 (1.99–5.60, p<0.001)	1.51 (0.79–2.80, p=0.204)	
Snacking	None	374 (9.9)	44 (7.2)	-	-	$\chi^2 = 7.8$ df = 6 p = 0.25
	1–2/week	1000 (26.5)	165 (26.9)	1.40 (0.99–2.02, p=0.060)	1.35 (0.92–2.02, p=0.132)	
	3–4/week	861 (22.8)	116 (18.9)	1.15 (0.80–1.67, p=0.470)	1.00 (0.67–1.53, p=0.994)	
	5–6/week	268 (7.1)	44 (7.2)	1.40 (0.89–2.18, p=0.143)	1.11 (0.68–1.84, p=0.669)	
	1/day	664 (17.6)	120 (19.5)	1.54 (1.07–2.24, p=0.022)	1.28 (0.85–1.96, p=0.247)	
	2/day	415 (11.0)	85 (13.8)	1.74 (1.19–2.59, p=0.005)	1.42 (0.92–2.23, p=0.119)	
	≥ 3/day	193 (5.1)	40 (6.5)	1.76 (1.11–2.80, p=0.016)	1.32 (0.77–2.25, p=0.307)	
Night meals	None	2105 (55.8)	303 (49.3)	-	-	$\chi^2 = 13.2$ df = 5 p = 0.021
	1–3/month	599 (15.9)	95 (15.5)	1.10 (0.86–1.41, p=0.443)	1.02 (0.77–1.34, p=0.904)	
	1–2/week	744 (19.7)	132 (21.5)	1.23 (0.99–1.53, p=0.063)	1.21 (0.94–1.55, p=0.145)	
	3–4/week	230 (6.1)	53 (8.6)	1.60 (1.15–2.19, p=0.004)	1.61 (1.10–2.33, p=0.012)	
	5–6/week	41 (1.1)	11 (1.8)	1.86 (0.90–3.54, p=0.071)	1.62 (0.70–3.48, p=0.238)	
	7/week	56 (1.5)	20 (3.3)	2.48 (1.44–4.12, p=0.001)	2.30 (1.21–4.22, p=0.009)	

**Notes:** Odds ratio (OR), 95% confidence intervals, and p-value are presented. OSA, obstructive sleep apnea. <sup>a</sup>Multivariable logistic regression: Dietary behaviors + Demographics and Lifestyle factors + Occupational factors (Detailed results of all variables are presented in [Table S3](#)).

a confounding factor in the relationship between skipping breakfast and sleep quality.<sup>30</sup> We collected data from military service members whose bedtime and meal times were almost identical since their regular sleep time was set from 10 pm to 6 am and the same meal was provided three times a day. Therefore, the data could be relatively independent of these confounding factors. In other studies, skipping breakfast was associated with shorter sleep duration in male workers aged 40–59 years,<sup>19</sup> and daily breakfast consumption was associated with sufficient sleep in children.<sup>44</sup> In addition, an intervention study reported that eating breakfast for seven days improved perceived sleep quality compared with skipping breakfast.<sup>45</sup> In our study, we collected the frequency of skipping breakfast during the week, and a higher frequency of skipping breakfast was generally associated with a greater likelihood of poor sleep quality. However, responders who skipped breakfast daily showed a lower tendency of being poor sleepers. It seems that skipping breakfast irregularly adversely affects the maintenance of circadian rhythms.

## Occupational Factors and Poor Sleep Quality

Some interesting occupational factors associated with poor sleep quality were observed in the participants. Our study included only enlisted personnel, most of them being in combat arms, and others being drivers, military chefs, or working in

the administration. Poor sleepers were relatively frequent among military chefs since they are expected to wake up early at dawn to prepare the food and therefore get extra sleep time in the late morning after work. Possible reasons for frequent poor sleep quality in these military chefs may be related to the fact that splitting sleep could negatively affect subjective sleep quality.<sup>46</sup> Contrarily, drivers had lower sleep disturbances, which can be explained by the efforts of the military to prevent vehicle accidents that could be caused by drowsy driving.<sup>47,48</sup> In Korea, drivers are rarely assigned to night sentry duties, and even if assigned, they are placed early in the night or early in the morning rather than in the middle of the night. The likelihood of lower sleep disturbances in drivers was significant, even after adjusting the frequency of night shifts. Policies implemented by the military seem to have been relatively effective in preventing sleep disorders among drivers.

Military rank was also related to sleep disturbances, with a private rank leading to a lower likelihood of experiencing poor sleep quality. In the Korean army, mandatorily enlisted personnel are of the private rank until the 8th week, and they receive basic military training courses during the first five to seven weeks. During these courses, enlisted personnel receive intensive physical training, maintain a constant schedule for sleep and meals, and cannot eat snacks or night meals. In the present study, those with private ranks who had just completed this training course showed a lower likelihood of experiencing poor sleep quality. Approximately 5–7 weeks of regular sleep/meal rhythms and intensive physical training may be related to a reduced number of poor sleepers. In support of this, regularizing the sleep-wake schedule was reported to improve subjective sleep efficiency in an experimental study.<sup>49</sup> However, a previous study showed that the duration of military service was a factor that increased the risk of insomnia symptoms.<sup>50</sup> This may partially explain the concluded results that first-class privates, corporals, and sergeants showed a higher tendency of experiencing sleep disturbances, compared to privates.

The night shift was a major factor involved in the development of sleep disturbances in previous studies.<sup>51,52</sup> When the frequency of night shift was > 5 times in one month, the likelihood of poor sleep quality significantly increased in this study.

## Dietary Behaviors and High Risk of OSA

### Overeating

Overeating was clearly associated with a high risk of OSA in the univariate logistic regression, but the tendency was diminished in the multivariable logistic regression. The association between overeating and the high risk of OSA seemed to be mainly explained by BMI because the strength of the association decreased after adjusting for BMI. Being overweight is a risk factor for OSA,<sup>53,54</sup> and frequent overeating can lead to a higher BMI.

### Night Meals

The effect of eating night meals on the high risk of OSA was significant after adjusting for BMI. Additionally, the odds ratio increased as the frequency of night meals increased. Previous studies have also reported that eating night meals adversely affects symptom severity in patients with OSA. Increased food intake in the evening was related to decreased sleep quality in patients with sleep apnea.<sup>55</sup> Additionally, patients with OSA who had a late dinner showed a higher apnea-hypopnea index (AHI) than those who had an early dinner.<sup>32</sup> Further, consuming fatty meals before bedtime significantly increased the AHI compared with light meals, in patients with OSA.<sup>56</sup> Considering the Republic of Korea army environment where this survey was conducted, military service members usually eat calorific foods such as fried chicken and pizza for night meals. Both the timing and characteristics of night meals appear to have a negative effect on OSA. Avoiding night meals appears to be an important dietary behavior that plays a role in preventing or alleviating sleep apnea.

### Skipping Breakfast

Skipping breakfast daily was clearly associated with a high risk of OSA. This behavior is different from the one associated with poor sleep quality, which involved irregular skipping behaviors. In a previous study that researched meal timing and sleep parameters in patients with OSA, skipping breakfast did not influence the severity of sleep apnea.<sup>32</sup> In contrast, in a different study of patients with obesity and OSA, higher caloric intake at breakfast was associated with lower AHI.<sup>55</sup> The reason for this association between skipping breakfast and high risk of OSA is unclear, but the potential factors include being overweight,<sup>57</sup> having hypertension,<sup>58</sup> and insulin resistance,<sup>58</sup> which are known to be related to the habit of skipping breakfast. Being overweight and having hypertension or insulin resistance are both risk factors for OSA.<sup>59,60</sup> Further research is required to explore the effects and mechanisms of skipping breakfast on OSA.

## Occupational Factors and High Risk of OSA

In the present study, sedentary workers in administrative positions showed a lower likelihood of being at high risk of OSA, compared with personnel in combat arms whose main tasks were special qualifications' training. In a study conducted in Korea, the prevalence of high risk of OSA was 10.7% in the white-collar group and 13.4% in the blue-collar group, but the difference between the two groups was not significant.<sup>61</sup> When comparing the characteristics of personnel in administration and combat arms, older age, higher educational level, and negative smoking status were observed in the administrative group (Table S4). Although the odds ratio of the administration group compared to the combat arms group was still below one after adjusting for all covariates, some reports suggest that a higher educational level is associated with a lower risk of OSA.<sup>62–64</sup> The characteristics of personnel in administrative positions may explain the lower risk of OSA; thus, further studies are required.

## Limitations and Implication

This study has several limitations. First, only men in their early 20s were included. Therefore, generalizing the results of this study to other sex and age groups is limited. Second, due to the limitations imposed by a cross-sectional design, it is difficult to demonstrate causality, and only an association can be derived. Third, poor sleep quality and high risk of OSA were defined using self-reported questionnaires. Fourth, objective sleep parameters were not included in this study.

Nevertheless, we successfully obtained practical data from a large population to understand the relationship between dietary behaviors and sleep quality. Although the association between sleep and dietary conditions should be comprehensively examined with various potential covariates, it is challenging when the type and amount of data are limited.<sup>65</sup> Therefore, our large-scale study using various symptom examination tools may provide a deep and broad understanding of the association between sleep and other factors, which could be a milestone for future studies (Table S5).

Additionally, these results may provide insights for military policymakers regarding the development of health promotion programs for military personnel. Based on our findings and related previous research, the dietary behaviors of military service members should receive attention to improve their sleep quality and prevent the risk of OSA. Especially, a policy to avoid frequent changes in meal timings (higher frequency of eating night meals or skipping breakfast) should be considered to improve sleep quality. In addition, an educational program to decrease the frequency of snacking and overeating can be developed to prevent the risk of OSA.

## Conclusion

In this large-scale cross-sectional study that included 4389 Korean military service members, eating a night meal 5–6 times/week, skipping breakfast irregularly, and eating snacks frequently were associated with poor sleep quality. Whereas, eating night meals and skipping breakfast daily were associated with a high risk of OSA. Irregular dietary behaviors appear to be related to poor sleep quality and a high risk of OSA. To determine the possible mechanisms related to the associations between sleep and dietary behaviors needs further research.

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## Disclosure

The authors report no conflicts of interest in this work.

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