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ORIGINAL PAPER

Associations between depressive symptom severity and dietary mineral intake in Korean young adults*

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Abstract

The aim of this study was to determine the severity of depressive symptoms in young adults and to investigate their association with dietary mineral intake. A total of 497 Korean young adults (246 males and 251 females), aged 19-39 years old, participated. Daily intakes of food, caloric, and 12 minerals, which were assessed using a 24-hour dietary recall, were compared between the high depressive symptom (HDS) group and the normal group; these two groups were classified according to the Center for Epidemiologic Studies Depression Scale (CES-D). The mean age of the subjects was 27.43 years for men and 27.11 years for women, with no significant difference; however, height, weight, and body mass index were significantly higher in men than in women. The food intake analysis revealed a significant difference in seaweed consumption between male HDS and normal groups (1.91 g vs. 5.48 g, respectively). No significant differences were found in total mineral intake between the HDS and normal groups. However, when the participants were subdivided according to their general characteristics, depressive symptom scores were found to be negatively correlated with the intake of several minerals, including phosphorus, potassium, and molybdenum. These findings suggest a potential association between dietary mineral intake and depressive symptom levels, highlighting the possible role of nutritional factors in mental health of young adults. However, further research on the association between mineral status and depressive symptoms in healthy adults is needed to suggest appropriate nutritional management for the prevention of depression.

Keywords: depressive symptom severity, mineral intake, food intake, young adults

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INTRODUCTION

Major depressive disorder, or depression, is a condition in which symptoms such as low mood, lethargy, and lack of interest last for more than two weeks and significantly interfere with daily life (World Health Organization 2022). Depression is one of the most common mental disorders observed in the community and in clinical practice (Chang et al. 2007); it affects approximately 5% of adults and 3.8% of the population worldwide as of 2019 (World Health Organization 2022). Because of the high societal costs of depression, its prevention, early detection, and treatment are critical.

Young adulthood is a time of independence from parents that involves establishing identity, exploring possibilities, and establishing values in areas of life such as love, career, and worldview (Barbayannis 2022). Negative experiences in the competitive and demanding work environment of modern society have increased stress and lowered self-esteem among young adults, leading to depression and other mental health problems (Jung et al. 2022, Ji et al. 2023). According to the Korean Mental Health Status Report, in 2020, depression was reported in 8.3% of adults in their 20s, 6.8% of adults in their 30s, 4.9% of adults in their 40s, 2.4% of adults in their 50s, 4.3% of adults in their 60s, and 5.3% of adults in their 70s and older, with the highest prevalence reported among adults in their 20s and 30s (National Center for Mental Health 2021).

Diet and nutritional status affect nervous system metabolism, and minerals in particular can directly influence the development and function of the nervous system by acting as cofactors or catalysts for various enzymes in the body (Badaeva et al. 2023, Quan et al. 2023). In previous studies examining the association between depressive symptoms and mineral intake, Chen et al. (2023) reported a negative association between selenium, potassium, and magnesium intake and depressive symptom scores, and Miki et al. (2015) reported a significant association between adequate calcium, iron, and zinc intake and a lower prevalence of depressive symptoms. Davison et al. (2012) reported no significant associations between depressive symptoms and calcium, magnesium, phosphorus, potassium, sodium, or zinc intake; however, they did report a significant negative association with iron intake. Taken together, these studies show that the associations between mineral intake and depressive symptoms are reported differently in different studies, and studies that consider various characteristics of the subjects must be conducted to establish more accurate and sufficient evidence.

The purpose of this study was to investigate the associations between depressive symptom levels and mineral intake in young adults to suggest the importance of and the need for adequate mineral intake for good mental health in young adults.

MATERIALS AND METHODS

Participants

This study was conducted among young adults in the Chungcheong area of Korea. After the purpose and content of the study were explained, 539 people who understood the study and agreed to participate were surveyed by nutritionists. The exclusion criteria were subjects outside of their 20s and 30s, energy intake of less than 500 kcal per day or more than 5,000 kcal per day, pregnant or lactating women, and subjects who answered ‘do not know’ or who did not respond to the survey questions. After 42 subjects who met the exclusion criteria were excluded, a total of 497 subjects (246 men and 251 women) were included in the statistical analysis. This study was approved by the Institutional Review Board of Kongju National University (KNU_IRB_2022-104). Written informed consent was obtained from all the subjects, and the study was conducted in accordance with the relevant guidelines.

General information survey

The general characteristics assessed included sex, age, height, weight, occupation, living arrangement, and average monthly income (or pocket money). Body mass index (BMI) was calculated from the height and weight surveyed and classified as normal or underweight (<23 kg m^{-2}), overweight (23-25 kg m^{-2}), or obese (>25 kg m^{-2}) according to the World Health Organization Asia–Pacific and Korean Society for Obesity criteria (Korean Society for the Study of Obesity 2022).

Assessment of depressive symptom severity

The Center for Epidemiological Studies-Depression Scale (CES-D), a comprehensive tool validated for reliability and validity, was used to assess depressive status. The CES-D consists of 20 items to assess depressive symptoms, with focus on depressive mood as experienced by the general population. All 20 items are scored on the frequency that they were experienced by the subject over the past week, using a scale of 0 for 1 day or less, 1 for 1-2 days, 2 for 3-4 days, 3 for 5-7 days; and the 4 items are reverse scored. The total possible score is 60 points, with higher scores indicating higher levels of depressive symptoms. The cutoff point used to categorize the high depressive symptom (HDS) and normal groups was 16, which is the cutoff point used in community epidemiologic surveys among the cutoff points (16, 21, and 25) suggested in previous studies (Cho et al. 1998, Jeon 2001, Kim et al. 2010, Park et al. 2011, Park et al. 2021).

Dietary intake survey

The dietary intake survey was conducted using a 24-hour recall method and included all foods consumed the day before the survey, as well as the type and amount of food consumed. To identify factors that may affect daily dietary intake, four additional questions were asked: whether the surveyed meal intake was representative of the participant's typical meal intake, whether vitamin and mineral supplements were taken, whether the participant was intentionally following a diet, and whether the participant had any dietary restrictions. The approximate amounts recorded on the questionnaires were converted to weight and the intake of energy and nutrients was calculated using CAN-Pro 5.0 (The Korean Nutrition Society, Seoul), and the intake of each food group was calculated on the basis of the food group classified in the ingredient code of the food. To improve the accuracy of the mineral intake assessment, the mineral content database was supplemented and analyzed according to a previous study (Yoon, Choi 2023). The mineral content of foods not analyzed in CAN-Pro 5.0 was analyzed using the mine ral databases of the National Institute of Agricultural Sciences (2021), the United States Department of Agriculture (2015), and Japan's Ministry of Education, Culture, Sports, Science and Technology (2015).

Statistical analysis

The statistical analysis was performed using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA). Frequencies were calculated for noncontinuous variables, and means and standard deviations were calculated for continuous variables. The subjects were categorized into the HDS group and the normal group on the basis of a depressive symptom score of 16, with a score of 16 or higher indicating higher depressive symptom and a score of 16 or lower being classified as normal. Differences between the HDS group and the normal group were tested for significance using unpaired t-test. The Pearson's correlation test was used to assess the correlation between variables, and a partial correlation test was used to assess the correlation after adjusting for sex, age, body mass index, occupation, residence type, income, and energy intake. All statistical significance was tested at the $p<0.05$ level.

RESULTS AND DISCUSSION

Depressive symptoms can lead to inappropriate dietary and lifestyle habits, which may result in nutrient deficiencies in the diet or an imbalance in dietary composition. Minerals, in particular, are essential for normal nervous system metabolism because they are involved in neurotransmitter production and chemical signaling. Daily dietary intake has the greatest impact on mineral nutrition in the body, so maintaining adequate mineral nutrition through a balanced diet is important. Therefore, the aim of this study was to assess the levels of depressive symptoms in young adults and to investigate their association with dietary mineral intake. The general characteristics of the participants are presented in Table 1, as previously reported (Yoon, Choi 2025). The mean age of the subjects was 27.43 years for men and 27.11 years for women, with no significant difference; however, height, weight, and BMI were significantly higher in men than in women (p<0.001). The distribution of obesity was significantly different between males and females, with a greater proportion of obese (41.06%) and overweight (27.24%) males than females and a greater proportion of below-normal (58.96%) females than males (p<0.001).

Table 1

General characteristics of the subjects

Variable	Criteria	All subjects (n=497)	Men (n=246)	Women (n=251)	p-value[!!!]
Age(years)		27.3±6.5[!]	27.4±6.4	27.1±6.5	0.587
Height(cm)		168.0±8.6	174.5±5.9	161.6±5.4	<0.001
Weight(kg)		67.2±14.6	75.1±12.5	59.5±12.2	<0.001
BMI[+] (kg m^{-2})		23.7±4.1	24.6±3.6	22.7±4.3	<0.001
Obesity degree[#]	normal or underweight	226(45.5)[!!]	78(31.7)	148(59.0)	<0.001
	overweight	107(21.5)	67(27.2)	40(15.9)	
	obesity	164(33.0)	101(41.1)	63(25.1)	
Residence type	with family	186(37.4)	87(35.4)	99(39.4)	0.410[^]
	alone	174(35.0)	83(33.7)	91(36.3)	
	dormitory	133(26.8)	74(30.1)	59(23.5)	
	others	4(0.8)	2(0.8)	2(0.8)	
Job	professional	43(8.7)	20(8.1)	23(9.2)	<0.001
	technician	41(8.2)	38(15.5)	3(1.2)	
	service	67(13.5)	15(6.1)	52(20.7)	
	student	274(55.1)	136(55.3)	138(55.0)	
	others	72(14.5)	37(15.0)	35(13.9)	
Income (USD/month)	<343	162(32.6)	74(30.1)	88(35.1)	0.432
	343-1370	139(28.0)	69(28.0)	70(27.9)	
	≥1370	196(39.4)	103(41.9)	93(37.0)	

[!] Mean±SD, [!!] n(%), [!!!] Unpaired t-test or χ^2-test, [^] Fisher's exact test, [+] Body mass index,
[#] BMI <23 – normal or underweight, 23-25 – overweight, ≥25 – obesity

As shown in Table 2, the average daily food intake of the subjects in this study was 1147.4 g, and food group intake among all the subjects was as follows: beverages > cereals > vegetables > meat > dairy products; this was

Table 2

Daily intake of food, energy, and nutrients of the subjects according to depressive symptom scores

Variable	All subjects (n=497)			p-value#	Men (n=246)		p-value	Women (n=251)		p-value
	total (n=497)	normal (n=341)	HDS (n=156)		normal (n=187)	HDS (n=59)		normal (n=154)	HDS (n=97)	
Total food(g)	1147.4±551.2^	1158.1±536.3	1123.9±583.4	0.521	1213.4±559.3	1251.1±785.0	0.733	1091.0±500.6	1046.4±401.7	0.461
Cereals	259.8±153.2	254.9±150.0	270.4±159.7	0.298	275.3±148.5	314.4±194.6	0.161	230.2±148.7	243.6±128.0	0.464
Potatoes and starches	32.1±51.5	32.1±51.9	32.2±50.8	0.990	35.9±52.0	26.9±34.0	0.126	27.5±51.6	35.4±58.6	0.266
Sugars and sweeteners	9.2±22.8	8.3±19.6	11.2±28.5	0.250	5.1±10.0	7.7±16.0	0.240	12.2±26.5	13.3±33.9	0.779
Pulses	27.0±56.4	25.5±53.6	30.4±62.1	0.394	22.7±49.5	24.6±46.0	0.789	28.9±58.1	33.9±70.1	0.557
Nuts and seeds	2.1±12.3	1.9±12.7	2.6±11.5	0.540	1.6±8.2	1.9±8.6	0.808	2.2±16.6	3.1±12.9	0.660
Vegetables	180.6±120.7	185.6±121.1	169.5±119.6	0.169	193.2±122.7	172.4±132.5	0.266	176.4±118.8	167.8±111.7	0.569
Mushrooms	4.1±12.2	3.6±10.9	5.2±14.7	0.242	2.5±8.2	4.3±16.5	0.425	5.0±13.4	5.7±13.6	0.687
Fruits	37.1±85.4	36.7±80.7	37.9±95.0	0.889	26.1±63.2	17.8±47.5	0.283	49.5±96.5	50.1±113.2	0.963
Meats	171.5±157.7	176.1±167.4	161.3±134.2	0.291	201.2±189.7	182.7±142.9	0.427	145.7±129.5	148.2±127.6	0.878
Eggs	36.1±47.9	35.8±47.4	36.6±49.1	0.869	38.6±52.6	32.5±43.1	0.418	32.5±40.1	39.1±52.5	0.290
Fishes	37.2±53.7	38.4±56.3	34.6±47.8	0.442	43.1±58.3	38.7±53.0	0.610	32.7±53.4	32.1±44.5	0.931
Seaweeds	3.6±12.9	3.8±13.6	3.3±11.5	0.686	5.5±17.8	1.9±9.2	0.044	1.7±4.1	4.2±12.6	0.069
Milks and dairy products	40.0±86.1	38.6±83.0	43.1±92.7	0.595	27.2±69.3	57.2±114.9	0.062	52.5±95.4	34.5±75.5	0.098
Oils and fats	9.7±15.3	9.1±13.2	10.9±18.9	0.288	8.7±9.4	8.4±14.1	0.893	9.6±16.8	12.4±21.3	0.276
Teas beverages alcohols	267.9±399.5	278.4±403.6	245.1±390.6	0.390	297.9±434.7	324.9±560.4	0.735	254.7±362.4	196.6±224.3	0.118
Seasonings	25.3±24.9	25.1±22.2	25.6±30.0	0.856	24.5±19.5	25.9±40.1	0.789	26.0±25.0	25.5±21.9	0.869
Energy (kcal)	1845.6±769.3	1839.7±743.4	1858.4±825.2	0.802	1960.2±753.1	1955.0±963.8	0.970	1693.5±706.7	1799.7±727.4	0.253
Carbohydrate (g)	221.5±90.4	219.1±87.5	226.7±96.5	0.383	234.8±89.0	236.5±110.8	0.914	200.1±82.1	220.8±86.7	0.058
Protein (g)	68.5±32.1	68.8±31.7	67.8±33.1	0.742	74.7±33.8	75.4±35.3	0.900	61.6±27.5	63.1±31.0	0.679
Fat (g)	63.5±40.4	63.2±40.0	64.2±41.6	0.798	66.5±42.4	61.0±38.1	0.383	59.3±36.6	66.1±43.6	0.180

^ mean±SD, # unpaired t-test, normal group – depressive symptom score <16, HDS (high depressive symptom) group – depressive symptom score ≥16 similar to the pattern of food group intake reported by Korea Health Statistics (2021). In this study, seaweed intake in the HDS group was significantly lower than that in the normal group among men (1.91 g vs. 5.48 g, $p<0.05$). Guo et al. (2019) evaluated depressive symptom levels according to seaweed intake over a 3-year follow-up period, and reported that depressive symptom scores and the prevalence of depressive symptoms did not differ significantly by seaweed intake level, but the incidence of depressive symptoms was significantly lower in the group whose seaweed intake increased. Miyake et al. (2014) analyzed seaweed consumption and depressive symptom levels in pregnant women and reported that higher seaweed consumption was associated with significantly lower depressive symptom levels. Seaweed can serve as a mineral source because its mineral content is more than 10 times higher than that of terrestrial plants (Lozano Muñoz et al. 2020). Yoon et al. (2022) analyzed the mineral content of seaweeds with high production in Korea and reported that various seaweeds, such as wakame, blue, prickly, tat, and green seaweed, had high levels of certain minerals and that the levels of copper, selenium, and iron in a single serving of some seaweeds exceeded the RDA for adult men aged 19-29 years old. Because seaweed is considered a rich source of minerals, it is possible that the low seaweed intake in the subjects with higher depressive symptom contributed to their low mineral intake. However, unlike the results for men, the trend was reverse in the female group, although it was not statistically significant. It may be because women tend to be more interested in dieting than men. Additionally, there were no significant differences between the HDS group and the normal groups in a variety of food groups other than seaweed that could also be sources of minerals, suggesting that a comparative assessment of mineral intake between the two groups is necessary and that further studies should be conducted to investigate the associations between seaweed intake and depressive symptom levels.

Table 3 shows the mineral intake of the subjects according to their level of depressive symptoms. The average daily mineral intakes for all the subjects were as follows: 363.30 mg of calcium, 874.54 mg of phosphorus, 2927.62 mg of sodium, 1848.88 mg of potassium, 242.28 mg of magnesium, 15.93 mg of iron, 11.87 mg of zinc, 487.19 μg of copper, 3.26 mg of manganese, 228.88 μg of iodine, 96.19 μg of selenium, and 117.62 μg of molybdenum. However, mineral intake did not differ significantly different between the HDS group and the normal groups for all subjects, regardless of sex. Because previous studies revealed differences in depressive symptoms and mineral intake according to general characteristics (Ilow et al. 2011, Jun et al. 2015, Kim et al. 2015, Jung et al. 2017, Jiang et al. 2020), we analyzed the associations between depressive symptom levels and mineral intake according to sex, age, and degree of obesity. As a result, depressive symptom levels were significantly negatively correlated with potassium (r=-0.11, $p<0.05$) in all subjects when adjusted for confounders, and were significantly negatively correlated with phosphorus (r=-0.13, $p<0.05$), potassium (r=-0.15,

Table 3

Daily mineral intake of the subjects according to depressive symptom scores

Variable	All subjects (n=497)			p-value[#]	Men (n=246)		p-value	Women (n=251)		p-value
	total (n=497)	normal (n=341)	HDS (n=156)		normal (n=187)	HDS (n=59)		normal (n=154)	HDS (n=97)	
Ca (mg)	363.3±236.3[^]	360.1±238.2	370.3±232.5	0.654	352.2±225.7	387.3±289.6	0.397	369.6±253.0	360.1±190.5	0.734
P (mg)	874.5±383.2	884.5±386.9	852.9±375.3	0.394	933.0±396.1	857.7±393.8	0.203	825.5±368.2	849.9±365.6	0.609
Na (mg)	2927.6±1498.7	2934.4±1535.9	2912.9±1418.7	0.882	3062.2±1578.9	3090.5±1607.8	0.905	2779.1±1472.0	2804.8±1287.2	0.888
K (mg)	1848.9±886.6	1876.9±891.0	1787.7±876.6	0.299	1933.7±923.5	1749.8±875.7	0.178	1807.9±847.9	1810.8±880.9	0.979
Mg (mg)	242.3±125.6	241.8±123.6	243.3±130.1	0.904	250.8±123.6	240.9±130.6	0.598	231.0±123.1	244.7±130.5	0.400
Fe (mg)	15.9±12.8	15.7±13.2	16.4±11.7	0.624	17.2±15.0	17.4±13.8	0.930	13.9±10.5	15.7±10.3	0.194
Zn (mg)	11.9±9.7	11.6±8.5	12.5±12.0	0.375	12.53±8.64	13.4±13.3	0.647	10.4±8.2	12.0±11.2	0.227
Cu (µg)	487.2±543.0	493.1±616.2	474.3±332.2	0.659	465.9±410.1	434.2±276.0	0.500	526.2±798.3	498.6±361.4	0.710
Mn (mg)	3.3±3.6	3.2±3.1	3.4±4.5	0.621	3.5±3.9	3.1±2.0	0.327	2.9±1.5	3.6±5.5	0.211
I (µg)	228.9±550.9	239.8±560.7	205.0±530.0	0.513	263.0±560.2	251.5±741.2	0.913	211.6±561.9	176.6±345.6	0.542
Se (µg)	96.2±54.5	95.0±53.0	98.8±57.7	0.477	102.5±56.2	106.8±63.3	0.622	85.9±47.5	93.9±53.0	0.218
Mo (µg)	117.6±63.1	118.1±64.9	116.5±59.3	0.795	128.0±64.6	115.9±62.9	0.209	106.2±63.5	116.9±57.4	0.177

[^] mean±SD, [#] unpaired t-test, normal group – depressive symptom score <16, HDS (high depressive symptom) group – depressive symptom score ≥16

$p<0.05$), and molybdenum (r=-0.18, $p<0.01$) intake in men. Depressive symptom levels were also significantly negatively correlated with phosphorus (r=-0.18, $p<0.05$) and potassium (r=-0.18, $p<0.05$) intake among subjects in their 30s and were significantly negatively correlated with potassium (r=-0.17, $p<0.05$) intake among obese individuals (Table 4). In terms of the characteristics of the subjects, depressive symptom levels were significantly negatively correlated with the intake of minerals such as phosphorus, potassium, and molybdenum, suggesting that there may be an association between depressive symptoms and mineral intake in certain subjects.

In a previous study on the relationship between depressive symptom levels and phosphorus nutritional status, Lee et al. (2021) reported that there was no significant difference in the nutrient density of phosphorus according to depressive symptom levels. On the other hand, Kaner et al. (2015) reported that the phosphorus intake of a group with depression was significantly lower than that of a normal group, and Thi-Thu-Nguyen et al. (2019) reported that the phosphorus density of a group with high levels of depressive symptoms was lower than that of a normal group in women and that phosphorus intake and depressive symptom levels were negatively correlated, which is similar to the finding of this study. Phosphorus is involved in skeletal development and is a major component of cell membranes and intracellular organelles (Berner et al. 1988), but research on its effects on the nervous system is lacking. Clinical deficiencies in phosphorus in healthy adults are characterized by extremely low intake or impaired metabolism of phosphorus in the body (EFSA Panel on Dietetic Products et al. 2018). Some studies that have examined the association between phosphorus nutritional status and depressive symptoms have not found significant results when the association between serum levels of phosphorus and depressive symptoms was analyzed by assessing nutritional status in individuals with medical conditions that may impair phosphorus metabolism (Vučković et al. 2021; Hamurcu. 2023). Therefore, further research on the association between phosphorus nutritional status and depressive symptoms in healthy adults is necessary to suggest appropriate phosphorus nutritional management for the prevention of depression.

The consumption of foods high in sodium and low in potassium may contribute to depression through a variety of mechanisms, including direct effects on neurotransmitters and neurological function (Mrug et al. 2019). Recently, Western diets high in sodium, saturated fat, and added sugars have been shown to have significant negative effects on behavior and cognition through damage to the frontal, limbic, and hippocampal regions of the brain, and these effects have been convincingly demonstrated in younger age groups (Dash et al. 2015, Fuhrmann et al. 2015). In a previous study of the association between actual depressive symptom levels and potassium intake, Chen et al. (2023) reported a negative association between potassium intake and depressive symptom scores; likewise, Park et al. (2018) reported that

Table 4

Correlation between depressive symptom scores and mineral intake based on subject characteristics

		Ca	P	Na	K	Mg	Fe	Zn	Cu	Mn	I	Se	Mo
All subjects		0.02 (0.738)[!]	-0.02 (0.595)	0.03 (0.581)	-0.05 (0.241)	-0.01 (0.806)	0.02 (0.581)	-0.01 (0.833)	0.02 (0.652)	-0.01 (0.840)	-0.02 (0.655)	0.02 (0.681)	-0.05 (0.290)
		-0.01 (0.791)[!!]	-0.08 (0.096)	0.01 (0.897)	-0.11 (0.019)	-0.04 (0.335)	0.03 (0.451)	-0.01 (0.870)	-0.01 (0.744)	-0.01 (0.842)	-0.01 (0.803)	0.02 (0.671)	-0.06 (0.199)
Sex	men (*n*=246)	0.04 (0.554)	-0.12 (0.091)	0.01 (0.877)	-0.13 (0.036)	-0.09 (0.169)	0.04 (0.530)	-0.03 (0.648)	0.00 (0.995)	-0.10 (0.117)	-0.00 (0.954)	-0.01 (0.838)	-0.18 (0.005)
		0.08 (0.236)[!!!]	-0.13 (0.038)	0.01 (0.829)	-0.15 (0.023)	-0.08 (0.225)	0.05 (0.445)	-0.01 (0.847)	0.03 (0.688)	-0.08 (0.225)	0.01 (0.926)	0.01 (0.844)	-0.18 (0.005)
	women (*n*=251)	-0.01 (0.873)	0.10 (0.131)	0.08 (0.222)	0.04 (0.537)	0.07 (0.241)	0.05 (0.395)	0.04 (0.517)	0.02 (0.791)	0.08 (0.189)	-0.01 (0.792)	0.11 (0.095)	0.12 (0.064)
		-0.09 (0.144)[!!!]	-0.03 (0.606)	-0.02 (0.725)	-0.06 (0.317)	-0.03 (0.683)	0.01 (0.917)	0.00 (0.977)	-0.04 (0.525)	0.05 (0.481)	-0.01 (0.910)	0.01 (0.839)	0.06 (0.317)
Age	20-29 years (*n*=300)	0.05 (0.356)	-0.02 (0.746)	0.02 (0.689)	-0.04 (0.470)	-0.02 (0.799)	0.05 (0.391)	-0.04 (0.454)	0.05 (0.433)	-0.07 (0.259)	-0.04 (0.447)	0.01 (0.826)	-0.06 (0.305)
		0.04 (0.536)[^]	-0.02 (0.691)	0.01 (0.917)	-0.07 (0.223)	-0.02 (0.714)	0.08 (0.197)	-0.03 (0.658)	0.04 (0.486)	-0.05 (0.367)	-0.05 (0.407)	0.03 (0.597)	-0.04 (0.460)
	30-39 years (*n*=197)	-0.04 (0.583)	-0.04 (0.568)	0.03 (0.722)	-0.07 (0.317)	0.01 (0.937)	-0.04 (0.621)	0.04 (0.615)	-0.00 (0.951)	0.07 (0.312)	0.01 (0.853)	0.03 (0.714)	-0.02 (0.774)
		-0.11 (0.138)[^]	-0.18 (0.013)	0.01 (0.922)	-0.18 (0.012)	-0.08 (0.264)	-0.09 (0.227)	0.02 (0.740)	-0.08 (0.288)	0.05 (0.537)	0.03 (0.648)	0.00 (0.977)	-0.09 (0.228)
Obesity degree	normal or underweight (*n*=226)	0.09 (0.167)	0.07 (0.295)	0.04 (0.586)	0.03 (0.661)	0.10 (0.138)	0.01 (0.923)	0.11 (0.109)	0.08 (0.262)	0.02 (0.767)	-0.08 (0.255)	0.13 (0.053)	-0.02 (0.816)
		0.04 (0.561)[#]	0.21 (0.755)	0.00 (0.946)	-0.06 (0.409)	0.03 (0.639)	0.00 (0.989)	0.09 (0.179)	0.04 (0.588)	0.00 (0.979)	-0.05 (0.439)	0.12 (0.066)	-0.07 (0.297)
	overweight (*n*=107)	-0.03 (0.742)	-0.03 (0.788)	0.05 (0.623)	-0.03 (0.788)	-0.04 (0.704)	-0.01 (0.913)	-0.03 (0.798)	-0.06 (0.533)	-0.01 (0.951)	0.14 (0.163)	0.06 (0.532)	-0.03 (0.732)
		-0.07 (0.490)[#]	-0.15 (0.12)	0.01 (0.972)	-0.13 (0.193)	-0.09 (0.193)	-0.04 (0.693)	0.00 (0.993)	-0.11 (0.271)	0.04 (0.708)	0.18 (0.078)	0.05 (0.642)	-0.03 (0.797)
	obesity (*n*=164)	-0.03 (0.672)	-0.12 (0.112)	-0.00 (0.989)	-0.16 (0.038)	-0.11 (0.152)	0.08 (0.332)	-0.15 (0.058)	0.01 (0.911)	-0.12 (0.126)	0.01 (0.872)	-0.12 (0.131)	-0.09 (0.253)
		-0.02 (0.757)[#]	-0.10 (0.218)	0.04 (0.592)	-0.17 (0.031)	-0.07 (0.362)	0.15 (0.056)	-0.11 (0.169)	-0.01 (0.893)	-0.08 (0.297)	-0.02 (0.846)	-0.09 (0.280)	-0.05 (0.549)

[!] correlation coefficient *r*(*p*-value), [!!] adjusted for sex, age, body mass index, job, residence type, income and energy intake, [!!!] adjusted for age, body mass index, job, residence type, income and energy intake, [^] adjusted for sex, body mass index, job, residence type, income and energy intake, [#] adjusted for sex, age, job, residence type, income and energy intake individuals with depression had significantly lower potassium intake and potassium intake per 1000 kcal than normal individuals did. Lee et al. (2021) also reported that individuals with depression had significantly lower potassium intake than normal individuals did, which is similar to the finding of our study. The main sources of potassium are green leafy vegetables, legumes, and seaweed, and in this study, seaweed intake was significantly lower in the group with depression than in the normal group. These dietary patterns may be related to the significant inverse association between depressive symptom levels and potassium intake, particularly among men, individuals in their 30s, and obese individuals. Future studies must be conducted to clarify these associations in different populations and to establish causality.

In a previous study on depressive symptom levels and molybdenum, Vyskočil et al. (1999) reported higher levels of molybdenum in the hair of individuals with depression, and Naylor et al. (1985) reported lower urinary molybdenum excretion in individuals with depression. Molybdenum is a coenzyme in the body that is involved primarily in redox reactions. Molybdenum deficiency manifests mainly as metabolic disorders caused by congenital defects in gene function, and its effects on the nervous system have been reported to cause neurodegeneration and brain damage (Schwarz et al. 2013). However, the role of molybdenum in depressive symptoms has been rarely studied, and the significant negative correlation between depressive symptom levels and molybdenum intake in this study, particularly in men, suggests that future research should focus on the effects of molybdenum intake on neuronal metabolism in relation to depressive symptoms.

Despite the need and timeliness of this study and its significant findings, it has several limitations. First, the study population was limited to those living in the Chungcheong region of South Korea, making it difficult to generalize to the young adult population. Second, the CES-D, which assesses depressive symptom levels, is a self-report questionnaire, which limits its ability to diagnose depression. In particular, the cutoff point used to identify subjects with high levels of depressive symptoms in this study was a community-based measure, which may have been less restrictive than a diagnosis of depression, thus diluting the association between depressive symptoms and mineral intake. Importantly, however, in this study, the levels of depressive symptom in young adults, a population with an increasing prevalence of depression, were assessed, and this study included the use of a database of the mineral content of various foods to provide a relatively accurate assessment of mineral nutrition. The findings of this study highlight the importance of dietary intake in the prevention and management of depression in young adults, a population whose prevalence continues to grow, and provide scientific evidence on the association between depressive symptoms and mineral intake.

CONCLUSIONS

The main finding of this study was that seaweed intake was significantly lower in the HDS group than in the normal group. In addition, depressive symptom levels were significantly negatively associated with the intake of minerals, such as phosphorus, potassium, and molybdenum, according to the subject characteristics. These results suggest an association with food and mineral intake and the importance of these dietary factors in depressive symptoms.

Author contributions

S.H.Y. – investigation, methodology, data curation, formal analysis, software, original draft preparation, review & editing; M.K.C – conceptualization, supervision, methodology, visualization, writing, review & editing. All authors have read and agreed to the published version of the manuscript.

Conflicts of interest

The authors of this study declare that there are no conflicts of interest.

REFERENCES

Badaeva, A.V., Danilov, A.B., Clayton, P., Moskalev, A.A., Karasev, A.V., Tarasevich, A.F., and Novikov, V.N. (2023) 'Perspectives on neuronutrition in prevention and treatment of neurological disorders' *Nutrients*, 15(11), 1-18, available: https://doi.org/10.3390/nu15112505

Barbayannis, G., Bandari, M., Zheng, X., Baquerizo, H., Pecor, K.W. and Ming, X. (2022) 'Academic stress and mental well-being in college students: Correlations, affected groups, and COVID-19', *Frontiers in Psychology*, 13, 1-10, available: https://doi.org/10.3389/fpsyg.2022.886344

Berner, Y. N., and Shike, M. (1988) 'Consequences of phosphate imbalance' *Annual Review of Nutrition*, 8(1), 121-148, available: https://doi.org/10.1146/annurev.nu.08.070188.001005

Chang, S.M., Sohn, J.H., Lee, J.H., Choi, J.H., Cho, J.H., Jeon, H.J., Hahm, B.J., Lee, D.H., and Cho, M.J. (2007) 'Characteristics of diagnostic criteria for depression in Korea' *Journal of Korean Neuropsychiatric Association*, 46(5), 447-452, available: https://koreascience.kr/article/JAKO200710103428929.page

Chen, S., Liu, J., Kang, X., Cui, K., and Zhang, D. (2023) 'Association of dietary mineral mixture with depressive symptoms: A combination of Bayesian approaches', *Preventive Medicine*, 175, 1-9, available: https://doi.org/10.1016/j.ypmed.2023.107661

Cho, M.J., Nam, J.J., and Suh, G.H. (1998) 'Prevalence of symptoms of depression in a nationwide sample of Korean adults', *Psychiatry Research*, 81(3), 341-352, available: https://doi.org/10.1016/S0165-1781(98)00122-X

Davison, K.M. and Kaplan, B.J. (2012) 'Nutrient intakes are correlated with overall psychiatric functioning in adults with mood disorders', *Canadian Journal of Psychiatry*, 57(2), 85-92, available: https://doi.org/10.1177/070674371205700205

EFSA Panel on Dietetic Products and Nutrition and Allergies (2015) 'Scientific Opinion on Dietary Reference Values for phosphorus', *EFSA Journal*, 13(7), 1-57, available: https://doi.org/10.2903/j.efsa.2015.4185

Fuhrmann, D., Knoll, L.J. and Blakemore, S.J. (2015) 'Adolescence as a sensitive period of brain development', *Trends in Cognitive Sciences*, 19(10), 558-566, available: https://doi.org/10.1016/j.tics.2015.07.008

Guo, F., Huang, C., Cui, Y., Momma, H., Niu, K. and Nagatomi, R. (2019) 'Dietary seaweed intake and depressive symptoms in Japanese adults: A prospective cohort study', *Nutrition Journal*, 18(58), 1-18, available: https://doi.org/10.1186/s12937-019-0486-7

Hamurcu, P. (2023) 'The Relationship of dietary nutrients with depression, anxiety and stress: A sample of nutrition and dietetics students', *Gevher Nesibe Journal of Medical and Health Sciences*, *8*(1), 190-201, available: http://doi.org/10.5281/zenodo.7601520

Ilow, R., Regulska-Ilow, B., Rozanska, D., Zatonska, K., Dehghan, M., Zhang, X. and Zatonski, W.A. (2011) 'Evaluation of mineral and vitamin intake in the diet of a sample of Polish population-baseline assessment from the prospective cohort 'PONS'study', *Annals of Agricultural and Environmental Medicine*, 18(2), 235-240, available: https://www.aaem.pl/Evaluation-of-mineral-and-vitamin-intake-in-the-diet-of-a-sample-of-Polish-population,71689,0,2.html

Jeon, K.K., Choi, S.J. and Yang, B.C. (2001) 'Integrated Korean version of CES-D development', *Korean Journal of Health Psychology*, 6(1), 59-76, available: https://accesson.kr/healthpsy/v.6/1/59/27362

Jiang, S., Ma, X., Li, M., Yan, S., Zhao, H., Pan, Y. and Li, B. (2020) 'Association between dietary mineral nutrient intake, body mass index, and waist circumference in US adults using quantile regression analysis NHANES 2007-2014', *PeerJ*, 8, e9127, available: https://peerj.com/articles/9127/

Jun, Y.S., Choi, M.K. and Bae, Y.J. (2015) 'Night eating and nutrient intake status according to residence type in university students', *Journal of the Korean Society of Food Science and Nutrition*, 44(2), 216-225, available: https://www.e-jkfn.org/journal/view.html?uid=5679&vmd=Full

Jung, S.Y., Lee, J.Y. and Kim, H. (2022) 'Associations between depressed mood with negative health behaviors of Koreans during the COVID-19 pandemic', *Journal of the Korea Convergence Society*, 13(4), 79-88, available: https://doi.org/10.15207/JKCS.2022.13.04.079

Jung, Y.M. and Choi, M.J. (2017) 'Nutrient intake according to weight gain during pregnancy, job status, and household income', *Clinical Nutrition Research*, 6(1), 27-37. available: https://doi.org/10.7762/cnr.2017.6.1.27

Kaner, G., Soylu, M., Yüksel, N., Inanç, N., Ongan, D. and Başmısırlı, E. (2015) 'Evaluation of nutritional status of patients with depression', *Biomed Research International,* 2015(1), 1-9, available: https://doi.org/10.1155/2015/521481

Kim, J.K. and Cho, K.J. (2010) 'Relationship between circadian type and level of depression: Mediating effect of sleep quality', *Korean Journal of Psychology: General*, 29(2), 355-370, available: https://accesson.kr/kpageneral/v.29/2/355/15715

Kim, Y.S. and Kim, B.R. (2015) 'Nutrient intake status of male and female university students in Chuncheon area', *Journal of the Korean Society of Food Science and Nutrition*, 44(12), 1856-1864, available: https://doi.org/10.3746/jkfn.2015.44.12.1856

Korean Society for the Study of Obesity (2022) 'Summary of the 8th Edition of the Clinical Practice Guidelines for Obesity 2022', *Korean Society for the Study of Obesity,* available: https://general.kosso.or.kr/html/?pmode=BBBS0001300003&seq=1383&smode=view.

Lee, E.J. and Kim, J.M. (2021) 'Association between depression and eating behavior factors in Korean adults: The Korea National Health and Nutrition Examination Survey 2018', *Journal of Nutrition and Health*, 54(2), 152-164, available: https://doi.org/10.4163/jnh.2021.54.2.152

Lozano Muñoz, I. and Díaz, N.F. (2020) 'Minerals in edible seaweed: health benefits and food safety issues', *Critical Reviews in Food Science and Nutrition*, 62(6), 1592-1607, available: https://doi.org/10.1080/10408398.2020.1844637

Miki, T., Kochi, T., Eguchi, M., Kuwahara, K., Tsuruoka, H., Kurotani, K., Ito, R., Akter, S., Kashino, I., Pham, N.M., Kabe, I., Kawakami, N., Mizoue, T. and Nanri, A. (2015) 'Dietary intake of minerals in relation to depressive symptoms in Japanese employees: The Furukawa Nutrition and Health Study', *Nutrition*, 31(5), 686-690, available: https://doi.org/10.1016/j.nut.2014.11.002

Miyake, Y., Tanaka, K., Okubo, H., Sasaki, S. and Arakawa, M. (2014) 'Seaweed consumption and prevalence of depressive symptoms during pregnancy in Japan: Baseline data from the Kyushu Okinawa Maternal and Child Health Study', *BMC Pregnancy and Childbirth*, 14(301), 1-7, available: https://doi.org/10.1186/1471-2393-14-3011

Mrug, S., Orihuela, C., Mrug, M. and Sanders, P.W. (2019) 'Sodium and potassium excretion predict increased depression in urban adolescents', *Physiological Reports*, 7(16), e14213, available: https://doi.org/10.14814/phy2.14213

National Center for Mental Health. (2021) 'National Mental Health Survey 2021' available: https://www.ncmh.go.kr/ncmh/board/boardView.do?fno=37&menu_cd=01_01&no=9289&bn=newsView#

Naylor, G.J., Smith, A.H.W., Bryce-Smith, D., and Ward, N.I. (1985) 'Trace elements in manic-depressive psychosis', *Journal of Affective Disorders*, 8(2), 131-136, available: https://doi.org/10.1016/0165-0327(85)90003-5

Park, H.R., Yoon, H.J. and Lee, J.H. (2018) 'Study on the relationship between nutrient intake and level of depressive symptoms – using data from the Korea National Health and Nutrition Examination Survey 2016', *Journal of Korean Dietetic Association*, 24(4), 283-297 available at: https://doi.org/10.14373/JKDA.2018.24.4.283

Park, J.H. and Kim, K.W. (2011) 'A review of the epidemiology of depression in Korea', *Journal of the Korean Medical Association*, 54(4), 362–369, available: https://doi.org/10.5124/jkma.2011.54.4.362

Park, K.A., Kim, J.W., Choi, O.J. and Song, K.H. (2021) 'Relationship among health interest, depression, and dietary habits of college students according to sex in Seoul and Gyeonggi areas', *Journal of the East Asian Society of Dietary Life*, 31(4), 213-225, available: https://doi.org/10.17495/easdl.2021.8.31.4.213

Quan, Z., Li, H., Quan, Z. and Qing, H. (2023) 'Appropriate macronutrients or mineral elements are beneficial to improve depression and reduce the risk of depression', *International Journal of Molecular Sciences*, 24(8), 1-20, available: https://doi.org/10.3390/ijms24087098

Schwarz, G. and Belaidi, A.A. (2013) 'Molybdenum in human health and disease', *Metallomics*, 13, 415-450, available: https://doi.org/10.1007/978-94-007-7500-8_13

Thi-Thu-Nguyen T., Miyagi S., Tsujiguchi H., Kambayashi Y., Hara A., Nakamura H., Suzuki K., Yamada Y., Shimizu Y., Nakamura H. (2019) 'Association between lower intake of minerals and depressive symptoms among elderly Japanese women but not men: Findings from Shika Study', *Nutrients*, 11(2), 1-13, available: https://doi.org/10.3390/nu11020389

Vučković, M., Radić, J., Gelemanović, A., Bučan Nenadić, D., Kolak, E., Dora Bu ˇ can B.N., and Radić, M. (2021) 'Associations between depression, nutritional status and Mediterranean diet in Dalmatian kidney transplant recipients' *Nutrients*, 13(12), 1-12, available: https://doi.org/10.3390/nu13124479

Vyskočil, A., Viau, C. (1999) 'Assessment of molybdenum toxicity in humans', *Journal of Applied Toxicology*, 19(3), 185-192, available: https://doi-org.libproxy.kongju.ac.kr/10.1002/(SICI)1099-1263(199905/06)19:3<185::AID-JAT555>3.0.CO;2-Z

World Health Organization. (2022) 'World Mental Health Report: Transforming Mental Health for All' available: https://www.who.int/news-room/fact-sheets/detail/depression

Yoon, S.H., Kim, S.Y., Park, E.S. and Choi, M.K. (2022) 'Nutritional assessment focusing on proximate composition and mineral content of Korean seaweeds', *Journal of the East Asian Society of Dietary Life*, 32(6), 321-329, available: https://doi.org/10.17495/easdl.2022.12.32.6.321

Yoon, S.H. and Choi, M.K. (2023) 'Dietary intake of minerals (Ca, P, Na, K, Mg, Fe, Zn, Cu, Mn, I, Se, and Mo) in young Korean adults with a self-selected diet', *Journal of Elementology*, 28(3), 671-685, available: https://doi.org/10.5601/jelem.2023.28.3.2394

Yoon, S.H. and Choi, M.K. (2025) 'Depressive symptoms, eating habits, and dietary quality among young adults in Chungcheong', *Nutrition Research and Practice*, 19(1), 55-65, available: https://doi.org/10.4162/nrp.2025.19.1.55