



Dietary Carotene Intake and Suicidal Ideation in Korean Females: Analysis of Data From the Korea National Health and Nutrition Examination Survey (2012, 2013, and 2015)

Eunji Lim^{1,2}, Bong-Jo Kim^{2,3}, Cheol-Soon Lee^{1,2}, Boseok Cha^{2,3}, So-Jin Lee^{2,3}, Ji-Yeong Seo¹, Jae-Won Choi³, Young-Ji Lee^{1,2}, Nuree Kang³, Seung Chan Kim⁴, and Dongyun Lee^{1,2} ✉

¹Department of Psychiatry, Gyeongsang National University Changwon Hospital, Changwon, Republic of Korea

²Department of Psychiatry, Gyeongsang National University, College of Medicine, Jinju, Republic of Korea

³Department of Psychiatry, Gyeongsang National University Hospital, Jinju, Republic of Korea

⁴Biostatistics Cooperation Center, Gyeongsang National University Hospital, Jinju, Republic of Korea

Objective The suicide rate in Korea was the highest among countries in the Organisation for Economic Co-operation and Development in 2019. In a previous study, higher intake of vegetables and fruits was associated with a lower risk of suicidal ideation, and carotene-rich fruits and vegetables lowered the risk of depression. This study aimed to examine the direct relationship between carotene intake and suicidal ideation, adjusting for the effect on depression.

Methods This study used data from the Korea National Health and Nutrition Examination Survey (KNHANES) conducted in 2012, 2013, and 2015. Carotene intake was assessed through a food intake frequency survey with a 24-hour recall. Suicidal ideation and depression were assessed using the mental health section of the KNHANES. We applied logistic regression to assess the relationship between carotene intake and suicidal ideation, adjusting for potential confounders.

Results A total of 5,480 females aged 19–64 years were included in this study. Carotene intake was significantly lower in the suicidal ideation group ($3,034.5 \pm 1,756.4$ $\mu\text{g/day}$) than in the nonsuicidal ideation group ($3,225.4 \pm 1,795.1$ $\mu\text{g/day}$) ($p=0.015$). We found a significant inverse association between carotene intake and the risk of suicidal ideation after adjusting for potential confounders (odds ratio=0.934, 95% confidence interval=0.873–0.999).

Conclusion These results suggest that carotene intake may be inversely associated with the risk of suicidal ideation. Our findings may inform the development of new nutritional interventions to prevent increases in the risk of suicide worldwide.

Psychiatry Investig 2023;20(10):897-903

Keywords Carotenoids; Suicidal ideation; Depression; Female.

INTRODUCTION

The suicide rate in Korea is the highest among the Organisation for Economic Co-operation and Development countries. In 2019, the suicide rate in Korea was 24.6 cases per 100,000 people.¹ In Korea, suicide is the leading cause of death among individuals in their 10s, 20s, and 30s and the second leading

cause of death among individuals in their 40s and 50s.² Suicide imposes social costs, such as loss of labor and economic power,³ and approaches to prevent suicide-related issues are needed. In this context, it is important to identify and prevent or improve modifiable risk factors for suicide. Various mental disorders, such as depressive disorder, substance use disorder, and mental and physical trauma, are the main risk factors for suicide.⁴ In addition, lifestyle factors that are related to nutrition and dietary patterns, such as being underweight or obese, excessive smoking, alcohol consumption, and low physical activity, are also associated with the risk of suicide.⁵

Previous studies have reported an association between food and suicidal ideation. Energy drinks; junk food;⁶ carbonated drinks; sweets such as candy, cakes, and chocolate;⁷ and the consumption of 4 or more cups of coffee a day⁸ have been found

Received: September 12, 2022 **Revised:** November 6, 2022

Accepted: November 16, 2022

✉ **Correspondence:** Dongyun Lee, MD, PhD

Department of Psychiatry, Gyeongsang National University Changwon Hospital, 11 Samjeongja-ro, Seongsangu, Changwon 51472, Republic of Korea
Tel: +82-55-214-3801, **Fax:** +82-55-214-3254, **E-mail:** yuny0829@gnu.ac.kr

© This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<https://creativecommons.org/licenses/by-nc/4.0>) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

to increase the risk of suicidal ideation. Research has also identified nutritional and dietary patterns that reduce the risk of suicide. A study investigated the relationship between dietary habits and suicide among 89,037 Japanese adults and found that diets involving a high intake of healthy foods such as vegetables, fruits, legumes, and fish lowered the risk of suicide.⁹ Additionally, in a study of 222,081 Korean individuals, subjects who ate vegetables and fruits more than once a day had an approximately 1.3- to 1.5-fold lower risk of suicidal ideation than subjects who did not eat vegetables and fruits at all or ate them less than once a day.¹⁰ Psychiatric diseases might affect the relationship between intake of healthy food and suicide-related issues.

Depression is one of the strongest risk factors for suicide.¹¹ Many previous studies have explored the relationship of depression with nutrient and dietary patterns. Consumption of instant and processed foods increased the risk of depression, whereas consumption of beta-carotene, vitamin B6, vitamin E, and vitamin C lowers the risk of depression.¹² A meta-analysis on the relationship between fruit and vegetable intake and depression suggested that the vitamins found in large amounts in fruits and vegetables may lower the risk of depression.^{13,14} As mentioned above, vitamins may act as protective factors against depression and reduce the risk of suicide.

Carotene, which is found in fruits and vegetables at levels up to 200 mg/kg, is one such vitamin associated with depression.¹⁵ In a study on the relationship between carotene intake and depression using data from the US National Health and Nutrition Examination Survey (NHANES), carotene intake lowered the risk of depression.^{16,17} Low blood carotene levels are a risk factor for depression,¹⁸ but studies on the association between suicidal ideation and carotene intake are scarce. Since suicidal ideation is not only a symptom of mental illness but also an independent psychiatric problem, it is important to examine the direct relationship between suicidal ideation and carotene intake. Females experience suicidal ideation more frequently than males,^{19,20} and have higher levels of suicidal ideation than there are suicide attempts.^{21,22} The purpose of this study was to investigate the relationship between carotene intake and suicidal ideation in females who are prone to experience suicidal ideation using data from the Korea National Health and Nutrition Examination Survey (KNHANES).

METHODS

Study population

The Korea Disease Control and Prevention Agency has administered the KNHANES since 1998 to investigate the general health and nutritional status of Korean individuals.²³ This study used data from the KNHANES conducted in 2012, 2013,

and 2015.²⁴ Among these data, data from 2012, 2013, and 2015 that included carotene intake per day and suicidal ideation were extracted and analyzed. Adult females between the ages of 19 and 64 years were included, and the total number of participants was 7,787. After excluding participants with missing values for questionnaire items relating to daily carotene intake and suicidal ideation, 5,480 females were included in the final analysis. All participants provide written informed consent, and the survey protocol was approved by the Korea Disease Control and Prevention Agency Institutional Review Board (IRB No. 2012-01EXP-01-2C, 2013-07CON-03-4C, 2013-12EXP-03-5C, 2015-01-02-6C).

Measurements and variable definitions

Suicidal ideation and depression

The mental health section of the KNHANES includes the question “Have you seriously considered suicide in the past year?” According to answers on this question, we classified participants into two groups, the suicidal ideation group and the nonsuicidal ideation group. The question about the experience of depression was as follows: “Have you ever felt sad or hopeless enough to interfere with your life for more than 2 weeks in a row in the past year?” If the subjects answered “yes” to the question, they were considered to have depression.

Dietary carotene intake

For carotene intake, responses to the KNHANES food frequency were used.²⁴ The total daily intake of dietary carotene ($\mu\text{g}/\text{day}$) was determined according to the intake frequency and quantity of 112 foods. The number of intakes per week and the average intake per standard serving for 112 foods were calculated and used to determine the subjects' carotene intake.

Covariates

To compare the socioeconomic characteristics and general medical conditions of the suicidal ideation group and nonsuicidal ideation group, these variables were divided into the following categories: age (19–38, 39–58, or 59–64 years), body mass index (BMI; <18.5, 18.5 to <25, 25 to <30, or ≥ 30 kg/m²), education level (less than elementary school, middle school, high school, or college or higher), marital status (married or single), income level (low, middle-low, middle-high, or high), smoking status (never, former, or current), alcohol consumption (less than once a month, 2–4 times a month, 2–3 times a week, or 4 or more times a week), and comorbid diseases such as hypertension and diabetes (yes or no).

Statistical analysis

The KNHANES data used in this study were extracted us-

ing two-stage stratified cluster sampling. In the data analysis, the complex structure of the sampling procedure was incorporated using weights. The scores of the suicidal ideation and nonsuicidal ideation groups were compared. The means of continuous variables were compared with a univariate generalized linear model, and the proportions of categorical variables were compared with the Rao-Scott chi-square test. Multivariate logistic regression analysis was performed after adjusting for factors that may affect suicidal ideation, such as age, BMI, education level, marital status, household income, smoking status, alcohol consumption, hypertension, diabetes, and depression. To analyze the risk of suicidal ideation according to carotene intake, standardized odds ratios (ORs) were calculated. For statistical analysis, the R package survey 4.1.2 (R Core Team. R Foundation for Statistical Computing, Vienna, Austria, 2021) was used, and a $p < 0.05$ was considered statistically significant.

RESULTS

Sociodemographic characteristics

Of the total subjects, 5,027 females were in the nonsuicidal ideation group, and 453 females were in the suicidal ideation group. Participants in the suicidal ideation group were significantly more likely to have depression (57.7%) than those in the nonsuicidal ideation group (10.4%) ($p < 0.001$). Carotene intake was significantly lower in the suicidal ideation group ($3,034.5 \pm 1,756.4$ $\mu\text{g}/\text{day}$) than in the nonsuicidal ideation group ($3,225.4 \pm 1,795.1$ $\mu\text{g}/\text{day}$) ($p = 0.015$). Among other variables, obesity (BMI ≥ 30 kg/m^2), low education level (\leq elementary school), single marital status, low household income, current and former smokers, and more frequent alcohol consumption were higher in the suicidal ideation group (Table 1).

Suicidal ideation according to carotene intake

The results of the multivariate logistic regression analysis revealed that BMI, marital status, carotene intake, and depression significantly influenced the risk of suicidal ideation. We found an inverse association between carotene intake and the risk of suicidal ideation after adjusting for potential confounders (OR=0.934, 95% confidence interval [CI]=0.873–0.999, $p = 0.048$). Subjects with BMI of 18.5 to < 25 kg/m^2 had a lower risk of suicidal ideation than subjects with BMI of ≥ 30 kg/m^2 (OR=0.421, 95% CI=0.225–0.789, $p = 0.007$). On the other hand, single subjects (OR=1.617, 95% CI=1.119–2.338, $p = 0.011$) and those who had depression (OR=11.272, 95% CI=8.752–14.516, $p < 0.001$) had a higher risk of suicidal ideation (Table 2).

Figure 1 presents a visual depiction of the adjusted risk of suicidal ideation according to carotene intake. A 1,000- μg increase in carotene intake was associated with an approximately

0.934-fold decrease in the risk of suicidal ideation ($p = 0.048$).

DISCUSSION

This study found that the risk of suicidal ideation was higher among females aged 19 to 64 years who experienced depression. However, the risk of experiencing suicidal ideation was reduced by 0.934-fold as carotene intake increased, even after adjusting for depression, which could affect the likelihood of suicidal ideation. Therefore, high carotene intake may prevent suicidal ideation in females even after adjusting for the effect of depression. In addition, other risk factors for female suicidal ideation included higher BMI and single marital status. No previous studies have explored the relationship between carotene intake and suicidal ideation, and this study is the first to analyze the relationship between carotene intake and suicidal ideation in females.

Depression is one of the main risk factors for suicide, and the results of this study suggest that carotene intake could directly protect against suicidal ideation (i.e., after adjusting for depression) rather than indirectly lowering the risk of suicidal ideation by reducing depressive symptoms. Antioxidants such as those contained in fruits and vegetables act as protective factors against suicide;²⁵ similarly, carotene is a type of antioxidant that can reduce the risk of suicide.

Oxidative stress is associated with diverse psychiatric disorders.^{26,27} Previous studies have analyzed the relationship between carotene intake and the risk of depression. In one large study, higher intake of alpha-carotene, beta-carotene, beta-cryptoxanthin, lycopene, and lutein with zeaxanthin as well as total carotenoids were associated with a 0.50- to 0.71-fold lower risk of depression.¹⁶ In another study, only beta-cryptoxanthin intake lowered the risk of depression.¹⁷ Specifically, when beta-cryptoxanthin intake exceeded 110 $\mu\text{g}/1,000$ kcal, the risk of depression was reduced 0.65-fold.¹⁷ Carotene acts as a protective factor against psychiatric disorders through its anti-inflammatory and antioxidant effects.^{16,28}

A previous meta-analysis showed that suicide-related issues were associated with neurotoxic effects such as inflammation and oxidative stress.²⁹ In another study, people with suicidal ideation had higher blood levels of oxidative stress biomarkers, including NADPH oxidase (NOX), advanced oxidation protein products (AOPP), and the oxidative stress index, than those without a history of suicidal ideation.³⁰ The higher the NOX and AOPP blood levels were, the greater the intensity of suicidal ideation.³⁰ Similarly, another study reported that the serum concentration of oxidative stress biomarkers were higher and antioxidant potential was lower in individuals who had attempted suicide than in those who had never attempted suicide.³¹ Because carotene has antioxidant properties, it can

Table 1. Demographic and clinical characteristics of participants according to suicidal ideation

Characteristic	Nonsuicidal ideation (N=5,027)	Suicidal ideation (N=453)	p	Total (N=5,480)
Age			0.800	
19–38 yr	1,755 (41.9)	163 (43.5)		1,918 (42.0)
39–58 yr	2,592 (48.7)	217 (47.3)		2,809 (48.6)
59–64 yr	680 (9.4)	73 (9.2)		753 (9.4)
BMI			<0.001	
≥30 kg/m ²	195 (3.9)	29 (8.3)		224 (4.3)
25 to <30 kg/m ²	1,134 (21.2)	105 (22.9)		1,239 (21.4)
18.5 to <25 kg/m ²	3,411 (68.2)	282 (58.3)		3,693 (67.3)
<18.5 kg/m ²	287 (6.7)	37 (10.6)		324 (7.0)
Education level			<0.001	
≤Elementary school	624 (9.6)	101 (18.1)		725 (10.4)
Middle school	516 (9.3)	45 (9.3)		561 (9.3)
High school	1,969 (41.2)	186 (46.8)		2,155 (41.7)
≥College	1,918 (39.9)	121 (25.8)		2,039 (38.6)
Marital status			0.003	
Married	4,236 (78.5)	357 (71.4)		4,593 (77.9)
Single	791 (21.5)	96 (28.6)		887 (22.1)
Household income			<0.001	
High	1,322 (25.4)	89 (19.7)		1,411 (24.9)
Middle-high	1,311 (26.2)	100 (21.3)		1,411 (25.7)
Middle-low	1,261 (25.2)	116 (25.1)		1,377 (25.2)
Low	1,133 (23.2)	148 (33.9)		1,281 (24.2)
Smoking status			<0.001	
Never	4,541 (88.7)	356 (74.3)		4,897 (87.5)
Former	246 (5.5)	38 (9.8)		284 (5.9)
Current	240 (5.8)	59 (15.9)		299 (6.7)
Alcohol consumption			0.001	
≤1 time/month	3,493 (67.6)	292 (62.0)		3,785 (67.1)
2–4 times/month	1,064 (22.2)	95 (23.0)		1,159 (22.3)
2–3 times/week	400 (8.8)	46 (10.9)		446 (9.0)
≥4 times/week	70 (1.4)	20 (4.2)		90 (1.7)
Hypertension			0.773	
No	3,214 (67.8)	284 (68.6)		3,498 (67.9)
Yes	1,813 (32.2)	169 (31.4)		1,982 (32.1)
Diabetes			0.065	
No	3,956 (80.8)	342 (76.7)		4,298 (80.4)
Yes	1,071 (19.2)	111 (23.3)		1,182 (19.6)
Carotene intake (µg/day)	3,225.4±1,795.1	3,034.5±1,756.4	0.015	3,209.6±1,792.6
Depression			<0.001	
No	4,522 (89.6)	191 (42.3)		4,713 (85.5)
Yes	505 (10.4)	262 (57.7)		767 (14.5)

Values are presented as the number (%) or mean±standard deviation. BMI, body mass index

Table 2. Multivariate logistic analysis of the relationship between carotene intake and suicidal ideation

	β	SE	OR (95% CI)	p
Age				
19–38 yr	Reference	Reference	Reference	
39–58 yr	0.167	0.187	1.182 (0.819–1.706)	0.373
59–64 yr	0.017	0.248	1.017 (0.626–1.654)	0.945
BMI				
≥ 30 kg/m ²	Reference	Reference	Reference	
25 to <30 kg/m ²	-0.637	0.329	0.529 (0.278–1.008)	0.053
18.5 to <25 kg/m ²	-0.864	0.320	0.421 (0.225–0.789)	0.007
<18.5 kg/m ²	0.033	0.349	1.034 (0.522–2.048)	0.925
Marital status				
Married	Reference	Reference	Reference	
Single	0.481	0.188	1.617 (1.119–2.338)	0.011
Alcohol consumption				
≤ 1 time/month	Reference	Reference	Reference	
2–4 times/month	0.048	0.166	1.050 (0.758–1.453)	0.771
2–3 times/week	-0.045	0.226	0.956 (0.614–1.487)	0.842
≥ 4 times/week	0.614	0.346	1.848 (0.938–3.638)	0.076
Hypertension				
No	Reference	Reference	Reference	
Yes	-0.279	0.142	0.756 (0.573–0.999)	0.050
Diabetes				
No	Reference	Reference	Reference	
Yes	0.179	0.155	1.197 (0.883–1.621)	0.247
Carotene intake	-0.068	0.035	0.934 (0.873–0.999)	0.048
Depression				
No	Reference	Reference	Reference	
Yes	2.422	0.129	11.272 (8.752–14.516)	<0.001

Adjusted for age, BMI, education level, marital status, household income, smoking status, alcohol consumption, hypertension, diabetes, and depression. β , unstandardized coefficient; SE, standard error; OR, odds ratio; CI, confidence interval; BMI, body mass index

reduce oxidative stress by removing reactive oxygen species and free radicals.³² The risk of suicide due to oxidative stress can be lowered through the intake of carotene, an antioxidant.

No previous studies have directly studied the relationship between carotene intake and suicidal ideation, but a previous study confirmed a relationship between carotene serum concentrations and suicide attempts. This study investigated the relationships of serum concentrations of vitamin E, vitamin C, and carotene with suicide attempts in 6,680 people aged 17–39 years.³³ Individuals who had attempted suicide had lower serum concentrations of carotene than those who had never attempted suicide.³³ The probability of having low serum concentrations of alpha-carotene and beta-cryptoxanthin as well as total carotenoids was 1.45, 2.12, and 2.34 times higher, respectively, in those who had attempted suicide.³³ In the same

study, the serum concentrations of the antioxidants vitamin C, lutein/zeaxanthin, and lycopene as well as total carotenoids were lower in those who had attempted suicide than in those who had never attempted suicide.³³ Similarly, the results of the present study suggest that the intake of carotene, an antioxidant, is a protective factor against suicidal ideation in females. Further studies, including direct analysis of suicidal ideation and serum concentration of carotene, are needed.

This study has several limitations. First, since this study analyzed daily carotene intake using the food intake frequency survey, recall bias might exist. Second, since this was a cross-sectional study, it is difficult to determine the causal relationship between carotene intake and suicidal ideation. Third, since the serum concentrations of various types of carotenes were not measured in this study, the direct association between spe-

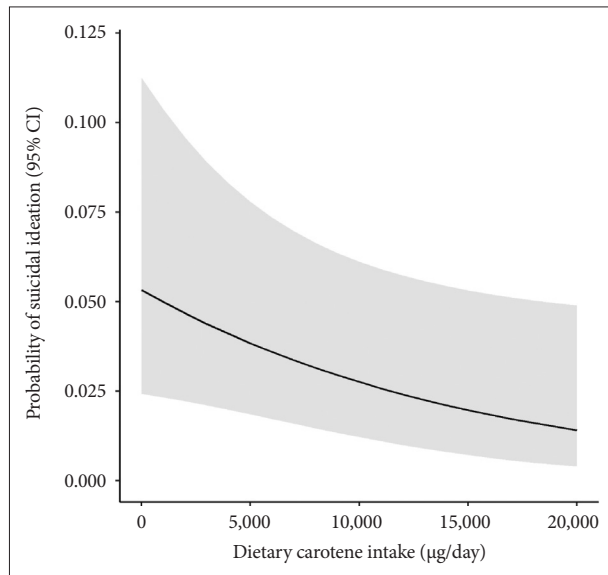


Figure 1. Dose-response relationship between dietary carotene intake and suicidal ideation. The association was adjusted for age, BMI, education level, marital status, household income, smoking status, alcohol consumption, hypertension, diabetes, and depression. The shadow indicates the 95% confidence interval (CI). BMI, body mass index.

cific carotene intake and suicidal ideation in females could not be confirmed. Further research on this is needed in the future. Fourth, although confounding factors that might affect suicidal ideation were adjusted for, other confounding factors may have influenced the results. Psychiatric diseases such as anxiety,³⁴ insomnia,³⁵ psychosis,³⁶ the socio-family environment, drug use, physical illness, and the suicide of relatives³⁷ could also influence the results. Fifth, this study was conducted only with females, and it is not representative of the entire population. Sixth, the main result was only marginally statistically significant (95% CI=0.873–0.999) and further studies confirming the relationship between carotene intake and suicidal ideation should be performed to replicate this finding.

Despite several limitations, this study is the first to analyze the relationship between carotene intake and suicidal ideation in females using large-scale data representative of Korean individuals. Oxidative stress is associated with the onset and course of several psychiatric disorders, and antioxidants such as vitamin C and vitamin D are known to supplement treatment of the disease. The results of this study are important as they suggest that carotene may be a novel antioxidant for preventing suicidal ideation. Further research examining the relationship between carotene intake and suicidal ideation that addresses the limitations of this study can inform the development of new nutritional interventions to prevent the risk of suicide, which is increasing worldwide.

Availability of Data and Material

The datasets generated or analyzed during the current study are available in the Korea National Health and Nutrition Examination Survey (KNHANES) repository, <https://knhanes.kdca.go.kr/knhanes/main.do>.

Conflicts of Interest

The authors have no potential conflicts of interest to disclose.

Author Contributions

Conceptualization: all authors. Data curation: Seung Chan Kim. Formal analysis: Eunji Lim, Dongyun Lee. Investigation: Cheol-Soon Lee. Methodology: Eunji Lim, Ji-Yeong Seo, Young-Ji Lee, Dongyun Lee. Project administration: Cheol-Soon Lee, Dongyun Lee. Resources: Cheol-Soon Lee. Supervision: Cheol-Soon Lee, Dongyun Lee. Visualization: Eunji Lim, Dongyun Lee. Writing—original draft: Eunji Lim. Writing—review & editing: all authors.

ORCID iDs

Eunji Lim	https://orcid.org/0000-0003-3967-8524
Bong-Jo Kim	https://orcid.org/0000-0003-2419-7306
Cheol-Soon Lee	https://orcid.org/0000-0003-1479-6962
Boseok Cha	https://orcid.org/0000-0002-3309-8863
So-Jin Lee	https://orcid.org/0000-0003-2904-9206
Ji-Yeong Seo	https://orcid.org/0000-0002-7329-8296
Jae-Won Choi	https://orcid.org/0000-0002-4516-1954
Young-Ji Lee	https://orcid.org/0000-0003-0201-2518
Nuree Kang	https://orcid.org/0000-0001-7630-4033
Seung Chan Kim	https://orcid.org/0000-0002-9210-9040
Dongyun Lee	https://orcid.org/0000-0002-3977-3663

Funding Statement

None

REFERENCES

1. OECD. Suicide rates. Available at: <https://data.oecd.org/healthstat/suicide-rates.htm#indicator-chart> [Internet]. Accessed August 31, 2022.
2. Statistics Korea. Causes of death statistics in 2019 [Internet]. Available at: http://kostat.go.kr/assist/synap/preview/skin/doc.html?fn=synapview385219_1&rs=/assist/synap/preview. Accessed August 12, 2022.
3. Doran CM, Kinchin I. Economic and epidemiological impact of youth suicide in countries with the highest human development index. *PLoS One* 2020;15:e0232940.
4. Mishara BL, Chagnon F. Why mental illness is a risk factor for suicide: implications for suicide prevention. In: O'Connor R, Pirkis J, editors. *The international handbook of suicide prevention* (2nd ed). Hoboken, NJ: John Wiley & Sons, Inc., 2016, p.594-608.
5. Berardelli I, Corigliano V, Hawkins M, Comparelli A, Erbutto D, Pompili M. Lifestyle interventions and prevention of suicide. *Front Psychiatry* 2018;9:567.
6. Park S, Lee Y, Lee JH. Association between energy drink intake, sleep, stress, and suicidality in Korean adolescents: energy drink use in isolation or in combination with junk food consumption. *Nutr J* 2016;15:87.
7. Pan X, Zhang C, Shi Z. Soft drink and sweet food consumption and suicidal behaviours among Chinese adolescents. *Acta Paediatr* 2011;100:e215-e222.
8. Park H, Suh BS, Lee K. Relationship between daily coffee intake and suicidal ideation. *J Affect Disord* 2019;256:468-472.
9. Nanri A, Mizoue T, Poudel-Tandukar K, Noda M, Kato M, Kurotani K, et al. Dietary patterns and suicide in Japanese adults: the Japan Public Health Center-based prospective study. *Br J Psychiatry* 2013;203:422-427.
10. Hwang IC, Choi S. Association between consumption of fruits and veg-

- etables with suicidal ideation. *Public Health Nutr* 2022;25:1285-1290.
11. Miret M, Ayuso-Mateos JL, Sanchez-Moreno J, Vieta E. Depressive disorders and suicide: epidemiology, risk factors, and burden. *Neurosci Biobehav Rev* 2013;37:2372-2374.
 12. Kim TH, Choi JY, Lee HH, Park Y. Associations between dietary pattern and depression in Korean adolescent girls. *J Pediatr Adolesc Gynecol* 2015;28:533-537.
 13. Liu X, Yan Y, Li F, Zhang D. Fruit and vegetable consumption and the risk of depression: a meta-analysis. *Nutrition* 2016;32:296-302.
 14. Saghafian F, Malmir H, Saneei P, Milajerdi A, Larijani B, Esmailzadeh A. Fruit and vegetable consumption and risk of depression: accumulative evidence from an updated systematic review and meta-analysis of epidemiological studies. *Br J Nutr* 2018;119:1087-1101.
 15. Jaiswal AK. *Nutritional composition and antioxidant properties of fruits and vegetables* (1st ed). Cambridge: Academic Press; 2020.
 16. Ge H, Yang T, Sun J, Zhang D. Associations between dietary carotenoid intakes and the risk of depressive symptoms. *Food Nutr Res* 2020;64:3920.
 17. Lin S, Shen Y. Dietary carotenoids intake and depressive symptoms in US adults, NHANES 2015-2016. *J Affect Disord* 2021;282:41-45.
 18. Milaneschi Y, Bandinelli S, Penninx BW, Corsi AM, Lauretani F, Vazzana R, et al. The relationship between plasma carotenoids and depressive symptoms in older persons. *World J Biol Psychiatry* 2012;13:588-598.
 19. Carrasco-Barríos MT, Huertas P, Martín P, Martín C, Castillejos MC, Petkari E, et al. Determinants of suicidality in the European general population: a systematic review and meta-analysis. *Int J Environ Res Public Health* 2020;17:4115.
 20. Cao XL, Zhong BL, Xiang YT, Ungvari GS, Lai KY, Chiu HF, et al. Prevalence of suicidal ideation and suicide attempts in the general population of China: a meta-analysis. *Int J Psychiatry Med* 2015;49:296-308.
 21. Monteith LL, Holliday R, Miller C, Schneider AL, Hoffmire CA, Bahraini NH, et al. Suicidal ideation, suicide attempt, and non-suicidal self-injury among female veterans: prevalence, timing, and onset. *J Affect Disord* 2020;273:350-357.
 22. Subramaniam M, Abdin E, Seow EL, Picco L, Vaingankar JA, Chong SA. Suicidal ideation, suicidal plan and suicidal attempts among those with major depressive disorder. *Ann Acad Med Singap* 2014;43:412-421.
 23. Korea Disease Control and Prevention Agency. Korean national health and nutrition survey [Internet]. Available at: https://knhanes.kdca.go.kr/knhanes/sub02/sub02_02.do. Accessed August 12, 2022.
 24. Korea Disease Control and Prevention Agency. Korea national health and nutrition examination survey (KNHANES). Available at: https://knhanes.kdca.go.kr/knhanes/sub03/sub03_02_05.do. Accessed August 12, 2022.
 25. Li Y, Zhang J, McKeown RE. Cross-sectional assessment of diet quality in individuals with a lifetime history of attempted suicide. *Psychiatry Res* 2009;165:111-119.
 26. Salim S. Oxidative stress and psychological disorders. *Curr Neuropharmacol* 2014;12:140-147.
 27. Hassan W, Noreen H, Castro-Gomes V, Mohammadzai I, da Rocha JB, Landeira-Fernandez J. Association of oxidative stress with psychiatric disorders. *Curr Pharm Des* 2016;22:2960-2974.
 28. Scapagnini G, Davinelli S, Drago F, De Lorenzo A, Oriani G. Antioxidants as antidepressants: fact or fiction? *CNS Drugs* 2012;26:477-490.
 29. Vasupanrajit A, Jirakran K, Tunvirachaisakul C, Solmi M, Maes M. Inflammation and nitro-oxidative stress in current suicidal attempts and current suicidal ideation: a systematic review and meta-analysis. *Mol Psychiatry* 2022;27:1350-1361.
 30. Koweszko T, Gierus J, Zalewska A, Maciejczyk M, Waszkiewicz N, Szulc A. The relationship between suicide and oxidative stress in a group of psychiatric inpatients. *J Clin Med* 2020;9:3462.
 31. Vargas HO, Nunes SO, Pizzo de Castro M, Bortolasci CC, Sabbatini Barbosa D, Kaminami Morimoto H, et al. Oxidative stress and lowered total antioxidant status are associated with a history of suicide attempts. *J Affect Disord* 2013;150:923-930.
 32. Fiedor J, Burda K. Potential role of carotenoids as antioxidants in human health and disease. *Nutrients* 2014;6:466-488.
 33. Li Y, Zhang J. Serum concentrations of antioxidant vitamins and carotenoids are low in individuals with a history of attempted suicide. *Nutr Neurosci* 2007;10:51-58.
 34. Bentley KH, Franklin JC, Ribeiro JD, Kleiman EM, Fox KR, Nock MK. Anxiety and its disorders as risk factors for suicidal thoughts and behaviors: a meta-analytic review. *Clin Psychol Rev* 2016;43:30-46.
 35. Harris LM, Huang X, Linthicum KP, Bryen CP, Ribeiro JD. Sleep disturbances as risk factors for suicidal thoughts and behaviours: a meta-analysis of longitudinal studies. *Sci Rep* 2020;10:13888.
 36. Harmer B, Lee S, Duong TVH, Saadabadi A. *Suicidal ideation*. Treasure Island, FL: StatPearls Publishing; 2021.
 37. Li Y, Li Y, Cao J. Factors associated with suicidal behaviors in mainland China: a meta-analysis. *BMC Public Health* 2012;12:524.