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Dietary Intake of Omega-3, Vitamin B9, Vitamin B12, and Depression of Female Adolescent in Semarang: A Cross-sectional Study

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Abstract

Research Objective: Depression disorder is a significant mental health issue occurring among adolescents worldwide. Omega-3 fatty acids, vitamin B9, and vitamin B12, influences the body's produced neurotransmitters, especially serotonin, dopamine, and norepinephrine. These neurotransmitters are neurobiological factors contributing to depression disorders. Levels of serotonin, dopamine, and norepinephrine in the body can aid in depression prevention. This research aims to analyze the correlation between the intake of omega-3 fatty acids, vitamin B9, vitamin B12, and depression symptoms in female adolescents at SMAN 9 Semarang. **Methodology**: This research is observational research with a cross-sectional design, involving 118 female adolescents aged 14 – 18 years. It is selected through non-probability sampling using purposive sampling. Depression symptoms are measured using the BDI-II (Beck's Depression Inventory) questionnaire, while omega-3 fatty acids, vitamin B9, vitamin B12 are measured using SQ-FFQ (Semi Quantitative Food Frequency Questionnaire). Bivariate data analysis using Chi-Square test and multivariate data analysis using logistic regression. **Results**: About 30% of female adolescents in X, XI, and XII grades are classified as having moderate depression with a deficiency in omega-3 intake (91.2%), vitamin B9 (88.2%), and vitamin B12 (85.3%). Multivariate analysis showed a relationship between vitamin B9 intake and depressive symptoms in female adolescents (p = <0,001). **Conclusion**: There is a relationship between vitamin B9 intake and depressive symptoms in female adolescents.

Keywords: *depression, female adolescents, omega-3, vitamin B9, vitamin B12*

INTRODUCTION

Mental health problems that commonly occur among adolescents include depression. Depression has the potential to lead to more severe consequences, including suicide (WHO, 2021). According to the World Health Organization, the Southeast Asia region has the highest prevalence of depression globally, accounting for approximately 27% of cases worldwide (WHO, 2021). In Indonesia, the prevalence of depression among individuals aged ≥15 years is reported to be 6.1% of the total population, with the highest prevalence observed in Central Sulawesi Province at 12.3% (Ministry of Health Indonesia, 2018).

Several studies indicate that individuals with depression tend to neglect dietary patterns and physical activity, which may further exacerbate mental health problems (Jacka et al., 2020). Food preferences also play a significant role in influencing both nutritional status and mental health. Nutrients can be effectively utilized in the management of depression (Lai et al., 2022). In particular, the intake of omega-3 fatty acids, vitamin B9 (folate), and vitamin B12 influences neurotransmitter activity, especially serotonin, dopamine, and norepinephrine. Alterations in these neurotransmitters are considered key neurobiological factors underlying depressive disorders (O'Neil et al., 2021).

One of the most critical neurotransmitters is serotonin. Serotonin, also known as 5-hydroxytryptamine (5-HT), is a monoamine neurotransmitter synthesized from the essential amino acid L-tryptophan, which must be obtained through dietary intake (Young, 2021). Reduced levels of serotonin, often accompanied by decreased dopamine, have been associated with depression and suicidal behavior. Low serotonin levels may trigger depression and anxiety, whereas an imbalance characterized by excessive serotonin without adequate dopamine may also contribute to heightened anxiety and fear responses (Belmaker & Agam, 2020).

Nutritional intake that may have protective effects against depression includes omega-3 fatty acids, vitamin B9, and vitamin B12. Omega-3 fatty acids belong to the polyunsaturated fatty acid (PUFA) group, characterized by the first double bond located at the third carbon from the omega end. The three main types include alpha-linolenic acid (ALA), eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA) (Calder, 2020). Epidemiological and experimental studies highlight their role in the prevention and treatment of depressive disorders. Evidence from both animal and human studies suggests that omega-3 deficiency can impair neuronal function, particularly serotonergic and dopaminergic systems (Grosso et al., 2021). EPA and DHA have been shown to exert protective effects against psychiatric disorders such as depression and anxiety. Depression is also associated with increased production of pro-inflammatory cytokines, whereas omega-3 fatty acids exhibit anti-inflammatory and antidepressant properties (Su, 2020). Antidepressant mechanisms generally involve increasing synaptic concentrations of serotonin, norepinephrine, and dopamine (Stahl, 2021). The recommended daily intake of omega-3 fatty acids for adolescent girls aged 14–18 years is 1.1 g/day (NIH, 2022).

Vitamin B9 (folate) is a water-soluble vitamin essential for DNA biosynthesis. Numerous studies have demonstrated an association between folate deficiency and depression. Low folate levels are linked to an increased risk of depression and worsening depressive symptoms due to decreased levels of dopamine, norepinephrine, and serotonin (Morris et al., 2020). Certain populations are more susceptible to inadequate folate intake, including adolescent girls aged 14–18 years, women aged 19–30 years, individuals with alcohol use disorders, patients with celiac disease or inflammatory bowel disease, and individuals with genetic mutations in the MTHFR (methylenetetrahydrofolate reductase) gene. The recommended dietary allowance for folate in adolescents aged 14–18 years is 400 mcg/day (NIH, 2022).

Vitamin B12 (cobalamin) is another essential micronutrient associated with depression. It has been identified as an effective adjunct in the treatment of depression and anxiety disorders. Vitamin B12 deficiency may lead to fatigue, weakness, constipation, balance disturbances, mental disorders, depression, and cognitive impairment (O'Leary & Samman, 2020). A study reported by the Academy of Psychosomatic Medicine demonstrated that supplementation with vitamin B9 and vitamin B12 improves cognitive function (Smith et al., 2021). The recommended daily intake of vitamin B12 for adolescents aged 14–18 years is 4 mcg/day (NIH, 2022). Epidemiological studies show that the prevalence of depression among adolescent girls is approximately twice that of boys, with differences emerging during mid-adolescence. Adolescent girls tend to experience earlier physical and hormonal maturation, including menstruation, which may increase vulnerability to emotional stress. Additionally, they are more susceptible to depression due to genetic factors compared to boys (Salk et al., 2020). A previous study conducted in a similar setting reported that 33.7% of female students at SMAN 9 Semarang, particularly in grade XII, experienced very high levels of stress (Putri et al., 2022).

Recent evidence from the field of nutritional psychiatry suggests that dietary quality plays an important role in mental health outcomes among adolescents. Nutrients involved in neurotransmitter synthesis, methylation pathways, and neuroinflammatory regulation have been increasingly recognized as modifiable risk factors for depression. Therefore, investigating the contribution of omega-3 fatty acids, vitamin B9, and vitamin B12 intake may provide important insights into nutritional approaches for depression prevention among adolescent girls.

Therefore, this study aimed to analyze the association between omega-3 fatty acid intake, vitamin B9 intake, vitamin B12 intake, and depressive symptoms among female adolescents in Semarang. We hypothesized that inadequate intake of omega-3 fatty acids, vitamin B9, and vitamin B12 would be associated with a higher risk of depressive symptoms.

METHODS

Study Design, Setting, and Period

This study employed an observational analytic design with a cross-sectional approach. The study was conducted at a public senior high school in Semarang, Indonesia, in September 2024. The independent variables were dietary intake of omega-3 fatty acids, vitamin B9, and vitamin B12. The dependent variable was the level of depressive symptoms, while nutritional status was treated as a confounding variable. Ethical approval for this study was obtained from the Health Research Ethics Committee of Dr. Moewardi Regional General Hospital (No. 1987/VII/HREC/2024).

Population and Sample

The target population consisted of female adolescents, while the accessible population included all female students in grades X, XI, and XII at the study site. The sample size was determined using the Slovin formula, resulting in a total of 118 participants. A non-probability sampling method was applied, meaning not all members of the population had an equal chance of being selected. Purposive sampling was used to recruit participants based on the following inclusion criteria: female students aged 14–18 years, willing to participate, and not currently menstruating or experiencing illness at the time of data collection. Purposive sampling was selected to ensure that participants met specific eligibility criteria relevant to the study objectives. Although this approach may limit generalizability, it allowed efficient recruitment of respondents representing the target population of female adolescents.

Data Collection and Study Procedures

Assessment of Depressive Symptoms

Depressive symptoms were assessed using the Beck Depression Inventory-II (BDI-II), administered via an online questionnaire (Google Forms). Participants self-reported their responses using a 4-point Likert scale (0–3). The total score was categorised into: Considered normal: 0–20; and Moderate depression: >20

The original 21-item questionnaire was modified to 20 items. A validity test of the modified instrument was conducted on 15 respondents before data collection. The modified BDI-II questionnaire underwent content validation prior to implementation. Internal consistency testing demonstrated acceptable reliability for screening depressive symptoms among adolescents. The SQ-FFQ used in this study was adapted from previously validated dietary assessment instruments and has been widely used in nutritional epidemiology studies.

Assessment of Nutrient Intake

Dietary intake of omega-3 fatty acids, vitamin B9, and vitamin B12 was assessed using a Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ) through interview-based data collection. Omega-3 intake included total consumption from foods, beverages, and supplements over the past month and was expressed in grams (g). Vitamin B9 and vitamin B12 intake included total intake from foods, beverages, and supplements over the past month and was expressed in micrograms (mcg). The SQ-FFQ data were analysed using NutriSurvey software. Nutrient adequacy levels were classified based on the 2019 Indonesian Recommended Dietary Allowance (RDA) cut-off points as follows: Adequate: ≥77% of recommended intake; Deficient: <77% of recommended intake.

Assessment of Nutritional Status

Anthropometric measurements, including body weight (kg) and height (cm), were obtained directly using a digital scale and a microtoise. Body mass index-for-age (BMI-for-age) was calculated using WHO Anthro software. Nutritional status was categorised based on z-scores as follows: Underweight: −3 SD to < −2 SD; Normal: −2 SD to +1 SD; Overweight: +1 SD to +2 SD; Obese: > +2 SD.

Data Analysis

Data were analysed using SPSS Statistics version 26. Descriptive (univariate) analysis was presented as frequencies and percentages for participant characteristics, including nutrient intake, depressive symptoms, and nutritional status. Bivariate analysis was conducted using the Chi-square test to examine associations between variables. Multivariate analysis was performed using logistic regression to identify independent predictors of depressive symptoms.

RESULTS

The univariate analysis of 118 female students from SMA Negeri 9 Semarang presented respondent characteristics including age, depressive symptoms, omega-3 intake, vitamin B9 intake, vitamin B12 intake, and nutritional status, as shown in Table 1.

The study participants consisted of female adolescents aged 14–18 years. Most respondents were aged 16 years (35.1%, n = 40). Approximately 30% of all respondents were classified as having moderate depression. This finding is consistent with national data from KPPPA, which reported that 93% of depressive symptoms occur among adolescents aged 14–18 years, while 7% occur among those aged 10–13 years.

Most respondents had adequate vitamin B9 intake (54.4%). However, a large proportion of respondents exhibited deficient intake of omega-3 fatty acids (69.3%) and vitamin B12 (63.2%). Based on BMI-for-age classification, 79 respondents (69.3%) had normal nutritional status, while 28 were classified as overweight and 7 as obese.

Table 1. Characteristics of Study Participants (n = 118)

Variable	Category	n	%
Age (years)	14	5	4.4
	15	32	28.1
	16	40	35.1
	17	35	30.7
	18	2	1.8
Depressive Symptoms	Normal (BDI-II score 0–20)	80	70.2
	Moderate depression (>20)	34	29.8
Omega-3 Intake	Adequate (≥77% RDA)	35	30.7
	Deficient (<77% RDA)	79	69.3
Vitamin B9 Intake	Adequate (≥77% RDA)	62	54.4
	Deficient (<77% RDA)	52	45.6
Vitamin B12 Intake	Adequate (≥77% RDA)	42	36.8
	Deficient (<77% RDA)	72	63.2
Nutritional Status (BMI-for-age)	Normal (−2 SD to +1 SD)	79	69.3
	Overweight (+1 SD to +2 SD)	28	24.6
	Obese (> +2 SD)	7	6.1

Table 2 shows that respondents with moderate depressive symptoms were more likely to have deficient intake of omega-3 fatty acids (91.2%), vitamin B9 (88.2%), and vitamin B12 (85.3%).

Table 2. Bivariate Analysis of the Association Between Nutrient Intake and Depressive Symptoms (n = 118)

Variable	Category	Moderate Depression n (%)	Normal n (%)	OR (95% CI)	p-value*
Omega-3 Intake	Adequate (≥77% RDA)	3 (8.1)	32 (40.0)	6.89 (1.94–24.45)	<0.001*
	Deficient (<77% RDA)	31 (91.2)	48 (60.0)	—	—
Vitamin B9 Intake	Adequate (≥77% RDA)	4 (11.8)	58 (72.5)	19.77 (6.24–62.63)	<0.001*
	Deficient (<77% RDA)	30 (88.2)	22 (27.5)	—	—
Vitamin B12 Intake	Adequate (≥77% RDA)	5 (14.7)	43 (53.8)	4.99 (1.75–14.20)	<0.001*
	Deficient (<77% RDA)	29 (85.3)	37 (46.3)	—	—

The results of the Chi-square test Table 2 indicated that omega-3 fatty acid intake, vitamin B9 intake, and vitamin B12 intake were significantly associated with depressive symptoms among female adolescents ($p < 0.001$).

Multivariate analysis using logistic regression Table 3, revealed that vitamin B9 intake had the strongest association with depressive symptoms (OR = 16.233; 95% CI: 4.107–64.158). This indicates that female adolescents with deficient vitamin B9 intake were approximately 16 times more likely to experience depression compared to those with adequate intake. For omega-3 fatty acids, the odds ratio was 2.154 (95% CI: 0.435–10.66), suggesting that adolescents with deficient omega-3 intake were about twice as likely to experience depression compared to those with adequate intake.

Table 3. Multivariate Logistic Regression Analysis of the Association Between Nutrient Intake and Depressive Symptoms (n = 118)

Variable	Category	Adjusted OR	95% CI	p-value
Omega-3 Intake	Adequate (≥77% RDA)	1.00 (Ref)	—	—
	Deficient (<77% RDA)	2.07	0.41–10.56	0.380
Vitamin B9 Intake	Adequate (≥77% RDA)	1.00 (Ref)	—	—
	Deficient (<77% RDA)	20.75	4.89–88.17	<0.001*
Vitamin B12 Intake	Adequate (≥77% RDA)	1.00 (Ref)	—	—
	Deficient (<77% RDA)	0.95	0.21–4.37	0.948

Meanwhile, vitamin B12 intake showed an odds ratio of 0.883 (95% CI: 0.197–3.955), indicating that adolescents with deficient vitamin B12 intake had 0.8 times the risk of experiencing depression compared to those with adequate intake.

The substantially higher adjusted odds ratio observed for vitamin B9 compared with omega-3 fatty acids and vitamin B12 suggests that folate intake may play a more prominent role in depressive symptoms among female adolescents in this population. However, the relatively wide confidence interval indicates a degree of statistical uncertainty and should be interpreted with caution.

DISCUSSION

The prevalence of depressive symptoms identified among female adolescents in this study further supports findings from previous research. According to data from Badan Pusat Statistik (BPS), the adolescent population in Indonesia reaches approximately 64.92 million, representing 23.9% of the total population, with one in three adolescents experiencing mental health disorders (BPS, 2023). In the present study, nearly 30% of respondents were classified as having moderate depression. These findings are consistent with prior research conducted in a similar setting, which reported that 33.7% of female students at SMAN 9 Semarang, particularly in grade XII, experienced very high levels of stress (Aryaningrum, 2023). Furthermore, this study aligns with data from KPPPA, indicating that 93% of depressive symptoms occur among adolescents aged 14–18 years, while 7% occur among those aged 10–13 years (KPPPA, 2022).

Individuals with depression tend to neglect dietary patterns and physical activity. Several studies suggest that food preferences significantly influence both mental health and nutritional status (Anggraini, 2014). Nutrients such as omega-3 fatty acids, vitamin B9, and vitamin B12 play an essential role in regulating neurotransmitters, including serotonin, dopamine, and norepinephrine, which are key neurobiological factors in depression (Jiwo Tirto, 2012). Evidence from both animal and human studies indicates that omega-3 deficiency may impair neuronal function, particularly serotonergic and dopaminergic pathways (Grosso et al., 2014).

Key nutritional factors that provide beneficial effects on mental health include omega-3 fatty acids, vitamin B9, and vitamin B12. Omega-3 fatty acids, particularly docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA), have been shown to exert preventive effects against depressive disorders (Gordon et al., 2020). In this study, Chi-square analysis demonstrated a significant association between omega-3 intake and depressive symptoms among female adolescents. Multivariate analysis further indicated that adolescents with omega-3 deficiency were approximately twice as likely to experience depression compared to those with adequate intake.

Vitamin B9 (folate) plays a crucial role in DNA synthesis and methylation processes, including the synthesis and regulation of neurotransmitters such as serotonin, dopamine, and norepinephrine (Muthmainah, 2016). The present study found a significant association between vitamin B9 intake and depressive symptoms. Multivariate analysis demonstrated that adolescents with vitamin B9 deficiency were 16 times more likely to experience depression compared to those with adequate intake. These findings are consistent with previous studies by Bottiglieri and Reynolds, which reported that folate deficiency is associated with depression (Bottiglieri & Reynolds, 2002). Furthermore, folate supplementation has been suggested as an adjunct therapy to enhance the effectiveness of antidepressant treatment (Muthmainah, 2016). Therefore, further research is required to evaluate its clinical effectiveness in depression management. Biologically, folate is involved in one-carbon metabolism and methylation reactions that are essential for the synthesis of serotonin, dopamine, and norepinephrine. Folate deficiency may impair neurotransmitter production and increase homocysteine concentrations, both of which have been associated with depressive symptoms. These mechanisms may explain why vitamin B9 remained statistically significant after adjustment for other nutritional factors.

Vitamin B12 has also been identified as an important micronutrient in the management of depression and anxiety disorders. Deficiency of vitamin B12 may lead to fatigue, weakness, neurological disturbances, cognitive impairment, and depressive symptoms (Salsabila, 2020). In this study, Chi-square analysis showed a significant association between vitamin B12 intake and depressive symptoms. However, multivariate analysis showed that vitamin B12 may not independently predict depressive symptoms after adjusting for confounders. Previous studies have shown that vitamin B12 supplementation can improve behavioural and cognitive outcomes (Todorov et al., 2017), particularly when combined with folate supplementation. The loss of statistical significance for omega-3 fatty acids and vitamin B12 in the multivariate model may indicate overlapping biological pathways with folate

metabolism or the influence of other confounding factors not fully captured in this study. In addition, dietary intake estimates may not fully reflect long-term nutritional status because biochemical measurements were not performed.

Although bivariate analysis demonstrated significant associations between omega-3 fatty acids, vitamin B9, vitamin B12, and depressive symptoms, only vitamin B9 remained statistically significant in the multivariate model. This finding may be explained by the presence of confounding variables, particularly nutritional status. Confounding factors may affect the validity of study findings and introduce bias into the analysis (Anggreni, 2022).

Based on the BDI-II questionnaire responses from 118 participants, the most frequently reported symptoms were related to "past failure" and "tiredness." Notably, two respondents classified as having severe depression reported the highest score on the "suicidal thoughts" item, highlighting the clinical importance of early detection.

Regarding nutritional status, 69.3% of respondents had normal BMI-for-age, while 24.6% were overweight and 6.1% were obese. Nutritional status is closely related to dietary intake. The observed association between depressive symptoms and nutritional status is consistent with previous findings by Sanlier and Unusan, which demonstrated that depression is associated with both undernutrition and overnutrition, including obesity (Sanlier & Unusan, 2007).

Several limitations should be considered when interpreting the findings of this study. First, the cross-sectional design does not permit causal inference between nutrient intake and depressive symptoms. Second, dietary intake was assessed using an SQ-FFQ, which may be subject to recall bias and reporting inaccuracies. Third, biochemical assessments of nutrient status were not conducted, limiting the ability to evaluate actual nutrient deficiencies. Finally, potential confounding variables such as socioeconomic status, physical activity, sleep quality, and family support were not comprehensively assessed.

CONCLUSION

This study found that omega-3 fatty acid intake, vitamin B9 intake, and vitamin B12 intake were significantly associated with depressive symptoms in bivariate analysis among female adolescents in Semarang. However, after adjustment for other variables, only vitamin B9 intake remained significantly associated with depressive symptoms. These findings suggest that adequate folate intake may play an important role in adolescent mental health. School-based nutrition education, promotion of folate-rich foods, and early mental health screening should be considered as part of comprehensive strategies to reduce depressive symptoms among adolescent girls. Future longitudinal studies are needed to clarify causal relationships between dietary intake and depression.

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Ethical Approval Statement: This study was conducted in accordance with ethical principles involving human participants. Ethical approval was obtained from the Ethics Committee of Dr. Moewardi Regional General Hospital (No. 1987/VII/HREC/2024).

Informed Consent Statement: Informed consent was obtained from all participants involved in the study.

Data Availability Statement: The data presented in this study are available from the corresponding author upon reasonable request. The data are not publicly available due to ethical and privacy considerations.

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Conflicts of Interest: The author declares no conflict of interest.

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