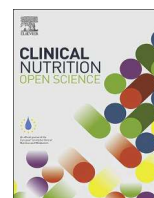




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Original Article

The relationship between prebiotic and probiotic foods consumption and the nutritional status of high school students aged 15–18: A cross-sectional study

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SUMMARY

Introduction: Adolescence experience rapid growth and requires optimal nutrition. Prebiotics and probiotics foods contribute to gut microbiota balance, influencing digestion and nutrient absorption which manifest on the nutritional status. However, the data intake of these foods among Indonesian adolescents remains limited. This study aimed to examine the association between consumption of prebiotic and probiotic food sources and nutritional status among high school students in West Java, Indonesia.

Methods: Design: A Cross-sectional analytic observational study.

Setting: SMA Negeri 2 Padalarang, West Bandung Regency, West Java, Indonesia.

Participants: 306 students (grades X–XII) selected through stratified random sampling. All completed the study. **Measurements:** A food frequency questionnaire assessed intake of prebiotic and probiotic sources. Nutritional status was determined using Body mass Index (BMI) for age.

Results: Fermented food ($r = -0.139$, $p = 0.015$) and vegetable consumption ($r = -0.477$, $p < 0.001$) were negatively associated with BMI, indicating higher intake corresponding with lower BMI.

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In Contrast, Cerealia ($r = 0.165$, $p = 0.004$) and chocolate products consumption ($r = 0.388$, $p < 0.001$) were positively associated with BMI. Meanwhile, fruit, nut, and legumes intake showed no significant relationship. Both prebiotic and probiotic intake accounted for 35.5% of the variation in nutritional status ($R^2 = 0.355$).

Conclusions: Consumption of fermented foods and vegetables is associated with lower BMI, while cereals and chocolate products are linked to higher BMI among adolescents. Dietary patterns involving prebiotic and probiotic sources may influence adolescent nutritional status. However, other contributing factors should be considered in future interventions.

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1. Introduction

The nutritional status of adolescents is an important indicator in determining the quality of health and development of the younger generation [1]. Adolescence is a critical phase characterized by rapid physical, psychological and social growth, resulting in increased nutritional needs. The balance between nutrient intake and needs greatly affects health status. Optimal nutrition supports cognitive development and endurance, while imbalances can lead to health problems, such as obesity and malnutrition with long-term effects. [1] Prebiotics and probiotics play a role in maintaining a healthy digestive system, which in turn contributes to nutritional status [2].

The immune system, metabolism, and general health are all dramatically impacted by the gut microbiota [3]. Prebiotics have been shown to enhance digestive health and encourage the growth of good bacteria in the gastrointestinal tract, mainly in the intestines, particular in the colon [4]. Prebiotics are indigestible food elements that help the host by promoting the development of beneficial bacteria in the gut, hence strengthening the immune system [2]. Probiotics, on the other hand, are live microorganisms that provide health benefits to the host when consumed in adequate amounts, mainly through maintaining gut microbiota balance and strengthening immune [5].

In Indonesia, adolescent food consumption patterns are still less than optimal, both in terms of quality and quantity [6]. The consumption of prebiotics from Cerealia, fruits, and vegetables is still relatively low, and also the consumption of probiotics derived from fermented-products [7]. Studies show that in 2014 household spending on probiotic products in Indonesia amounted to only US\$7, placing it in the bottom 4 in Asia Pacific [6]. *Badan Pengawas Obat dan Makanan (BPOM)* or the food and drug regulatory of Indonesian, (2018) on Food Consumption Figure states that the amount of fermented milk, including yoghurt, consumed by Indonesians is 155 grams per person per day, although this number is expected to increase every year [7]. Compared to consumption in developed countries, the figure of 155 grams can be said to be lower, especially if Indonesians have not reached optimal consumption to get the maximum benefit from probiotics. Therefore, further research is needed on the relationship between prebiotic and probiotic foods consumption and the nutritional status of adolescents.

Although various studies have examined the health benefits of prebiotics and probiotics, there are limited studies that specifically link the consumption of prebiotic and probiotic food sources with the nutritional status of adolescents in Indonesia. Several international studies have shown that consumption of foods high in prebiotics and probiotics can improve nutrient absorption and maintain energy balance in the body [2]. This study aims to explore the relationship between prebiotic and probiotic foods consumption on the nutritional status of SMA 2 Padalarang students. It is hoped that the results of this study can be the basis for recommendations for a healthier diet for adolescents and

encourage the development of local probiotic products that suit the needs of the Indonesian adults and adolescents.

2. Methods

2.1. Study design and setting

This study employed a cross-sectional analytic observational design conducted at SMAN 2 Padalarang, located in West Bandung Regency, West Java, Indonesia. The research aimed to assess the association between the consumption of prebiotic and probiotic food sources and the nutritional status of high school students.

2.2. Participants and sample size

The study population included all students enrolled in grades X to XII at SMA Negeri 2 Padalarang. The minimum required sample size ($n = 289$) was calculated using correlation study formula with a significance level α of 0.05, power of 80% and an assumed moderate effect size ($r = 0.3$). Samples were selected using stratified random sampling techniques to compensate for potential non-response with division based on class (10(X), 11(XI), and 12(XII)). The total number of samples included in this study was 306 students.

Inclusion criteria were students aged 15–18 years, attending school regularly, and providing informed consent (or parental consent for minors). Exclusion criteria included students with chronic illnesses or those taking dietary supplements during the study period.

2.3. Data collection instruments

2.3.1. Dietary intake of prebiotic and probiotic foods consumption assessment

Nutrient intake data were collected using the Food Frequency Questionnaire (FFQ) designed to assess the consumption of prebiotic and probiotic food sources (e.g., fruits vegetables, cereals, legumes, fermented foods). The instrument was adapted from previous validated questionnaires used in adolescents nutrition studies [8]. All items in the questionnaire have been tested for validity and reliability test on the other population. The FFQ items indicate that all indicators have a significance value of less than 0.05, and reliable with Cronbach's Alpha >0.60 (Probiotic Cronbach's Alpha = 0.968; Prebiotic Cronbach's Alpha = 0.985), confirming that all items in the questionnaire are valid and reliable. (data supplementary.1).

2.3.2. Anthropometric and nutritional assessment

Anthropometric measurements were taken to assess students' nutritional status, including height (cm), body weight (kg), body mass index (BMI) (kg/m^2), muscle mass (%), body fat percentage (%), and daily defecation frequency. Muscle mass and body fat percentage were measured using a calibrated bioelectrical impedance analysis (BIA) scale, while weight was measured using a calibrated digital scale (± 0.1 kg), and height was measured with a stadiometer (± 0.1 cm). Nutritional status was determined based on BMI-for age (BMI/A) according to WHO 2007 growth reference standards.

2.3.3. Ethical considerations

The study was approved by the Ethics Committee of Faculty of Medicine, Maranatha Christian University's with ethical clearance number 116/KEP/VIII/2024. All participants received a research information sheet and signed an informed consent prior to participation. For students under 18 years, parental consent was obtained in accordance with ethical guidelines.

2.3.4. Data analysis

Data were analyzed using statistical tests, SPSS version 26.0, (IBM Corp., Armonk, NY, USA). Data normality was tested using Kolmogorov-Smirnov test due to most variables not normally distributed.

Spearman's rank correlation was used to assess the relationship between prebiotic and probiotic foods consumption and nutritional status. In addition, to control for confounding variable and food consumption categories (fermented products, cereals, chocolate products, fruits, vegetables, nut and legumes) as independent variables. The significance level was set at $p < 0.05$.

3. Results

3.1. Participant characteristics

A total of 306 students (grades X-XII) participated in the study, all participants completed the questionnaire and anthropometric measurements. The participants were aged 15–18 years with a mean age of 16.2 ± 1.0 years. The gender distribution was 58% female and 42% male. Overall, the mean BMI-for-age-z-score was within the normal range, although 17.6% of students were classified as overweight or obese, and 9.1% were underweight based on WHO growth references.

3.2. Normality Test

Kolmogorov-Smirnov tests showed that most variables were not normally distributed ($p < 0.05$, see Table 1 and Figure 1). Therefore, Spearman's rank correlation was applied to assess relationships between prebiotic and probiotic foods consumption and nutritional status.

3.3. Correlation coefficient criteria

Coefficient values were categorized as shown in Table 2 to interpret the strength of correlations.

3.4. Correlation between food group intake and nutritional status

Table 1 presents the correlations between prebiotic and probiotic food consumption categories and BMI-for age tested by Kolmogorov-Smirnov with significance value < 0.05 , which means that all data used is not normally distributed. Next, the regression test conducted a non-parametric test, namely the Spearman rank regression test (see Table 3). The constant value (Intercept) is 1.461 with a Sig value. 0.002 ($p < 0.05$), indicating that the constant is statistically significant. This means, when all independent variables are 0, the predicted value of the dependent variable is 1.461. The correlation between each food's consumption can be seen on Table 3.

Fermented products. Coefficient $B = -0.007$ with Sig. 0.000 ($p < 0.05$), which means that the variable "Fermentation" has a significant negative effect on the dependent variable. That is, every one unit increase in the Fermentation variable will decrease the dependent variable by 0.007.

Table 1

One-sample Kolmogorov smirnov test for normality of prebiotic and probiotic food group consumption and nutritional status Variables ($n = 306$)

N		Nutritional status	Fermented food	Cerealia	Chocolate and products	Fruits	Nuts and legume	Vegetables
		306	306	306	306	306	306	306
Normal	Mean	.14	148.08	52.32	8.10	156.28	34.17	123.31
Parameters a,b	Std. Deviation	1.227	38.992	16.385	3.616	36.836	17.315	28.583
Most Extreme	Absolute	.168	.163	.085	.188	.123	.134	.089
Differences	Positive	.088	.163	.085	.188	.099	.121	.054
	Negative	-.168	-.073	-.036	-.095	-.123	-.134	-.089
Test Statistic		.168	.163	.085	.188	.123	.134	.089
Asymp. Sig. (2-tailed)		.000c	.000c	.000c	.000c	.000c	.000c	.000c

Note: The Kolmogorov-Smirnov test was used to assess the normality of data distribution for each variable, $p < 0.05$, indicates non-normal distribution, since most variables were not normally distributed, non-parametric analyses (Spearman's correlation and regression) were applied in subsequent test.

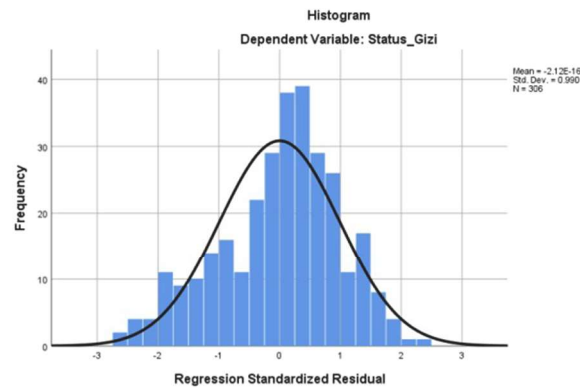


Figure 1. Normality Test: histogram above showed data not distributed normally.

Table 2

Interpretation criteria for correlation coefficient strength in Spearman's rank correlation analysis

Correlation coefficient	Criteria
0,00–0,199	Very Low
0,20–0,399	Low
0,40–0,599	Medium
0,60–0,799	Strong
0,80–1,000	Very Strong

Note: Correlation Strength was categorized as follows: 0.00–0.199 – very low, 0.20–0.399 = low, 0.40–0.599 = moderate, 0.60–0.799 = strong, 0.80–1.000 = very strong. These criteria were used to interpret the strength of associations between prebiotic and probiotic group consumption and nutritional status.

Cerealia. Coefficient $B = 0.014$ with Sig. 0.001 ($p < 0.05$) shows that the “Seria” variable significantly improves the dependent variable. The dependent variable rises by 0.014 for every unit increase in the Cerealia variable.

Chocolate and products. Coefficient $B = 0.072$ with Sig. 0.000 ($p < 0.05$), indicating a significant positive effect of the variable “Chocolate” on the dependent variable. Each one unit increases in the variable Chocolate increases the dependent variable by 0.072.

Fruits. At the 5% significance level, the variable “Fruit” has no discernible impact on the dependent variable, according to the coefficient $B = 0.002$ with Sig. 0.116 ($p < 0.05$). This means that variations in the Fruit variable have no meaningful impact on the dependent variable.

Nuts and legumes. Coefficient $B = -0.001$ with Sig. 0.822 ($p < 0.05$), indicating that the variable “Nuts” has no significant effect on the dependent variable. Variations in the Nut variable have no meaningful impact on the dependent variable.

Vegetables. Coefficient $B = -0.016$ with Sig. 0.000 ($p < 0.05$), indicating a significant negative effect of the variable “Vegetable” on the dependent variable. Each one unit increase in the Vegetable variable decreases the dependent variable by 0.016.

Constant. The coefficient of constant (intercept) is 1.061 with Sig values. 0.000 ($p < 0.005$), indicating statistically significant. That is when the independent variable “fermented products” is 0, the predicted value of the dependent variable “Nutritional Status” is 1.061. The calculated t value is $3.919 > 1.97$ t table value, so it can be concluded that fermentation has an influence on nutritional status.

Fermented products. With a sig value of 0.000 ($p < 0.05$) and a B coefficient of -0.006 , the variable “Fermentation” has a significant negative impact on the dependent variable “Nutritional Status”.

Table 3
Spearman's rank correlation between probiotic and prebiotic food group consumption and nutritional status among Indonesian high school students (n = 306)

Correlations	Fermented products	Cerealia	Chocolate and products	Fruits	Nuts and legume	Vegetables	Nutritional status
Spearman's rho	Fermented products	.396 ^a	.101	.194 ^a	.482 ^a	.121 ^b	-.139 ^b
		Correlation Coefficient					
		1.000					
		Sig. (2-tailed)					
		N					
	Cerealia	.396 ^a	.258 ^a	.310 ^a	.549 ^a	-.082	.165 ^a
		Correlation Coefficient					
		1.000					
		Sig. (2-tailed)					
		N					
	Chocolate and products	.258 ^a	1.000	.034	.388 ^a	-.379 ^a	.388 ^a
		Correlation Coefficient					
		1.000					
		Sig. (2-tailed)					
		N					
	Fruits	.194 ^a	.034	1.000	.184 ^a	-.058	.028
		Correlation Coefficient					
		1.000					
		Sig. (2-tailed)					
		N					
	Nuts and legumes	.482 ^a	.388 ^a	.184 ^a	1.000	-.044	.047
		Correlation Coefficient					
		1.000					
		Sig. (2-tailed)					
		N					
	Vegetables	.121 ^b	-.379 ^a	-.058	-.044	1.000	-.477 ^a
		Correlation Coefficient					
		1.000					
		Sig. (2-tailed)					
		N					
	Nutritional Status	-.139 ^b	.388 ^a	.028	.047	-.477 ^a	1.000
		Correlation Coefficient					
		1.000					
		Sig. (2-tailed)					
		N					

Note: Spearman's rank correlation was used to examine associations between probiotic and prebiotic food group consumption and nutritional status (BMI-for-age). P = correlation coefficient; p < 0.05 indicates statistical significance; p < 0.01 (**) denotes highly significant correlation; p < 0.05 (*) denotes significant correlation. Meanwhile, Negative correlations that higher food intake is associated with lower BMI-for-age and positive correlations indicate that higher food intake is associated with higher BMI.

^a Correlation is significant at the 0.01 level (2-tailed).

^b Correlation is significant at the 0.05 level (2-tailed).

In other words, the value of Nutritional Status". In other words, the value of Nutritional Status will drop by 0.006 for every unit rise in the Fermentation variable (Tables 4–8).

Comparison of F count with F table. The F table value (2.21) is significantly smaller than the computed F value (28.275). This shows that the independent variables (vegetable, cereal, fruit, chocolate, and nut) can considerably explain the variability in the dependent variable (nutrition status) using the regression model.

Model Significance. The significance value of 0.000 ($p < 0.05$) indicates that the F-test results are statistically significant. This means that there is a significant relationship between the independent variables (Vegetable, Cerealia, Fruit, Chocolate, Nuts) and the dependent variable (Nutrition Status).

This regression model is feasible and statistically negligible to predict the dependent variable based on the independent variables included. Therefore, the effect of the independent variables on the dependent variable is significant.

Comparison of F count with F table. The F table value (2.10) is significantly smaller than the computed F value (27.438). This shows that the independent variables (Vegetable, Grain, Fruit, Fermented, Chocolate, Nut) can considerably explain the variability in the dependent variable (Nutritional Status) through the regression model.

Model Significance. The significance value of 0.000 (<0.05) indicates that the F-test results are statistically significant. This means that there is a significant relationship between the independent variables (Vegetables, Cerealia, Fruits, Fermented products, Chocolate and products, Nuts and legume) and the dependent variable (Nutritional Status).

This regression model is feasible and statistically significant to predict the dependent variable based on the independent variables included. Therefore, the effect of the independent variables on the dependent variable is significant, and this model can be used to analyze the relationship between the independent variables and Nutrition Status convincingly.

Table 4

Multiple linear regression analysis of prebiotic and probiotic foods consumption predicting nutritional status

Model		Unstandardized coefficients		Standardized coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.461	.473		3.090	.002
	Fermented products	-.007	.002	-.222	-4.016	.000
	Cerealia	.014	.004	.191	3.374	.001
	Chocolate and products	.072	.019	.213	3.723	.000
	Fruits	.002	.002	.075	1.575	.116
	Nuts and legumes	-.001	.004	-.014	-.225	.822
	Vegetables	-.016	.002	-.374	-6.817	.000

Dependent Variable: Nutritional Status.

Table 5

Simple linear regression analysis of fermented food consumption and nutritional status among Indonesian high school students

Model		Unstandardized coefficients		Standardized coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.061	.271		3.919	.000
	Fermented Products	-.006	.002	-.198	-3.528	.000

Note: Dependent variable = Nutritional Status (BMI-for-age). Model tests the individual contribution of fermented food intake to nutritional status $p < 0.05$, indicates statistical significance. Negative coefficients indicate that higher fermented food intake is associated with lower BMI-for-age.

^a Dependent Variable: Nutritional Status.

Table 6
Prebiotic food group ANOVA (F-Test) predicting nutritional status among Indonesian high school students

Anova ^a						
Model		Sum of squares	Df	Mean square	F	Sig.
1	Regression	147.090	5	29.418	28.275	.000 ^b
	Residual	312.122	300	1.040		
	Total	459.212	305			

Note: The ANOVA test showed that the regression model including vegetable, cereal, fruit, chocolate, and nut consumption was statically significant ($F(5,300) = 28.275, p < 0.001$). This indicates that these prebiotic food groups collectively predict variations in nutritional status (BMI-for-age) among participants.

^a Dependent Variable: Nutritional Status.

^b Predictors: (Constant), Vegetables, Cerealia, Fruits, Chocolate, Nuts and legumes.

Table 7
Overall ANOVA (F-Test) of prebiotic and probiotic food group consumption predicting nutritional status among Indonesian high school students

Anova ^a						
Model		Sum of squares	Df	Mean square	F	Sig.
1	Regression	163.061	6	27.177	27.438	.000 ^b
	Residual	296.151	299	.990		
	Total	459.212	305			

Note: The overall regression model including vegetables, cereals, fruits, fermented products, chocolate, and nuts was statistically significant ($F(6,299) = 27.438, p < 0.001$). The combined variables explained approximately 35.5% ($R^2 = 0.355$) of the variance 1 nutritional status, while the remaining 64.5% may be attributed to other lifestyle or genetic factors.

^a Dependent Variable: Nutritional Status.

^b Predictors: (Constant), Vegetable, Cereal, Fruit, Fermented Food, Chocolate, and Nuts and legumes.

Table 8
Coefficient of Determination (R^2) for the regression Model Predicting Nutritional Status Among Indonesian High School Students ($n = 306$)

Model summary ^b				
Model	R	R square	Adjusted R square	Std. Error of the estimate
1	.596 ^a	.355	.342	.995

Note: The regression model including vegetables, cereals, fruits, fermented foods, chocolate products, and nuts explained 35.5% ($R^2 = 0.355$) of the variance in nutritional status (BMI-for-age), with and adjusted R^2 of 0.342. The remaining 64.5% of variability may be attributed to other unmeasured factors such as physical activity, sleep, genetics and overall diet quality.

^a Predictors: (Constant), Vegetables, Cerealia, Fruits, Fermented foods, Chocolate and products, Nuts and legumes.

^b Dependent Variable: Nutritional Status.

Based on the results of testing the coefficient of determination, it states that changes in nutritional status can be explained by the variables of Probiotic and Prebiotic foods Consumption by 35.5%. The remaining 64.5% is caused by other variables outside the two variables that are not involved in this study.

4. Discussion

The present study found significant associations between the consumption of specific prebiotic and probiotic foods and the nutritional status of Indonesian high school students. Notably, higher intake of fermented foods and vegetables was associated with lower BMI-for-age, while greater consumption of cereals and chocolate products was associated with higher BMI-for-age. These findings align with previous evidence that dietary fiber and probiotic-rich foods can improve gut microbiota composition and energy balance regulation, thereby preventing excessive weight gain

among adolescent [9,10]. Moreover, this study suggests that consumption of vegetables and fermented foods such as yoghurt or tempeh contribute to healthier nutritional status, in this case characterized by lower BMI values. This can be explained because the fiber content in vegetables and probiotics in fermented foods can help improve gastrointestinal health, improve metabolism, and provide a longer feeling of satiety, thus preventing overeating [9]. One Meta-analysis state that yoghurt might reducing the risk of obesity by 44% by consuming 165 gr per day dose dependent [10]. Similarly, a cross-sectional study in Poland found that regular consumption of fermented dairy products such as yoghurt was associated with healthier BMI and lower body fat percentage in children and adolescents, supporting the role of probiotics in maintaining metabolic balance [11].

From a microbiological and biochemical perspective, the relationship may be attributed to specific strains of probiotics commonly found in fermented foods. For example, *Lactobacillus plantarum*, [12] *Lactobacillus acidophilus*, [13] and *Bifidobacterium species*, [14] which are prevalent in yoghurt and fermented soy products like tempeh, have been shown to regulate lipid metabolism, modulate inflammatory responses, and support gut barrier integrity [12–14]. This mechanism may collectively contribute to better weight regulation and reduced adiposity storage. Moreover, some strains, such as *Lactobacillus rhamnoses GG*, have demonstrated anti-obesity effects through modulation of gut microbiota composition and reduction of fat mass in clinical studies [15,16]. Besides, the richness of probiotics content of yoghurt, it also content high amount of calcium that might regulate fat metabolism inhibiting fat cell to hypertrophy and trigger apoptosis in mature fat cell [17,18]. Calcium also enhances thermogenesis effect that increase energy expenditure, help body to excrete fecal fat and influence gut microbiota to balance the energy absorption and extraction [17,19].

Similarly, vegetables are rich in various forms of prebiotics, such as input, *fructooligosaccharides* (FOS), and *galactooligosaccharides* (GOS) [20]. These are non-digestible carbohydrates that selectively promote the growth and activity of beneficial gut microbiota. The fermentation of probiotics in the colon produces short-chain fatty acids (SCFAs), such as acetate, propionate, and butyrate, which play crucial role in regulating appetite, glucose homeostasis, and fat storage. SCFAs can also interact with gut-brain axis signaling pathways, promoting satiety and potentially reducing caloric intake [21,22].

In opposite, the consumption of chocolate and Cerealia was associated with an increase in BMI. This is most likely due to the high energy content of chocolate-especially processed chocolate that contains a lot of sugar and fat-and cereals that are commonly consumed in instant or sweetened processed forms, such as breakfast cereals with added sugar. These can significantly increase daily calorie intake when consumed in excess [23]. However, these results may vary depending on the type of cereal consumed. A systematic review found that regular consumption of whole-grain or unsweetened ready-to-eat cereals was associated with improved better weight control [24]. This finding suggest that the nutritional quality and processing methods of cereal products play significant role in determining the health impact of its food category Another form of Cerealia such as rice, ube or sweet potato, etc. if consumed unwisely also might contribute to high calory intake and glucose spike that might potentially cause insulin resistance [25]. Moreover, Asians has phenotypic evidence for having a progression of insulin resistance due to impaired carbohydrate tolerance to rice and starchy foods as the high intake of carbohydrates on the daily diet [26]. Indonesia governments also should review the potential policy brief of sugar tax to be implemented on food regulation to prevent overconsumption of carbohydrates.

Fruit consumption showed no significant association with nutritional status in this study. This can be explained because fruit, while rich in vitamins, minerals and fiber, also contains natural sugars such as fructose that still contribute calories. Both individuals with low and high BMI can consume similar amounts of fruit, so there is no significant difference. Furthermore, moderate consumption of fruit is considered healthy, but excessive consumption, especially in the form of juice, may increase total sugar intake and potentially impact nutritional status [27].

The results of the regression analysis showed that only about one-third of the variation in nutritional status could be explained by the consumption of prebiotic and probiotic foods. This suggests that although diet plays an important role, there are other factors such as physical activity, sleep patterns, stress and genetics that also affect a person's nutritional status [28]. However, this study highlights the potential role of specific food components-fermented foods and vegetables-in modulating adolescent weight status by their BMI per age.

This study has several limitations that should be considered. The dietary assessment relied on self-reported data obtained through a Food Frequency Questionnaire (FFQ), which may introduce recall bias and affect the accuracy of reported intake. Moreover, other important lifestyle factors were not recorded. Future studies employing longitudinal designs and objective measurements are recommended to validate these findings and provide stronger evidence for the observed association.

5. Conclusion

This study showed that the consumption of fermented foods and vegetables as sources of prebiotics and probiotics was negatively associated with nutritional status, indicating that higher intake of these two types of foods corresponded with the lower the BMI values of the respondents – indicating a trend towards a healthier reflecting a healthier or more balanced body weight. Conversely, greater consumption of cereals and chocolate products showed a positive association with higher BMI, suggesting a likelihood of being overweight when consumed excessively. Meanwhile, the consumption of prebiotic food groups – including fruits, nuts, and legumes–has shown no significant relationship with BMI. Overall, the intake of prebiotic and probiotic-rich foods contributed to 35.5% of the variation in nutritional status, indicating their meaningful role in weight regulation. Nevertheless, other lifestyle and behavioral factors should be explored in future studies to provide more comprehensive understanding of adolescent nutritional status.

Declaration of competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.nutos.2025.12.004>.

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