

Original article:

Daily Intake of *Advanced Glycation End Products*, Fibers and Vitamin C: Their Relationship with Nutrition Status in Adolescent Girls

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Abstract:

Introduction: Eating habits including food choice are responsible for malnutrition problem in Indonesia. For example, fast foods are very popular in adolescent life, especially who lives in urban areas. The objective of this research is to analyze the relationship of daily intake of Advanced Glycation End products (AGEs), fibers and vitamin C with nutrition status in adolescent girls. **Methods:** This cross sectional study was conducted in 150 adolescent girls of senior high schools who were in grade X and XI in Kediri city, East Java Province. Data of AGEs, fibers and vitamin C intake were determined using a 24h food recall questionnaire for two alternating days. Nutrition status was based on body mass index for age based on the z-score issued by the Indonesian Ministry of Health. The chi square and multiple logistic regression test was used to analyze the relationship of those variables with nutrition status. The significant level was set up at p value < 0.05. **Results:** The prevalence of overweight and obese was 26% in adolescent girls. Inadequate daily intake of fibers and vitamin C was commonly found in adolescent girls whilst AGEs were highly consumed by adolescent girls. AGEs intake (OR=1.85; 95% CI: 0.88-3.85; p=0.101), fiber intake (OR=0.92; 95% CI: 0.43-1.99; p= 0.839) and vitamin C intake (OR=0.85; 95% CI: 0.36-1.99; p=0.710) were positively related to nutrition status but it was not statistically significant. **Discussion:** High intake of AGEs and low intake of fiber and vitamin C increases the risk of overweight and obese in adolescent girls, compared to those who have low intake of AGEs and high intake of fibers and vitamin C but it was not statistically significant.

Keywords: Daily intake of AGEs, fibers, vitamin C, nutrition status, adolescent girls.

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Introduction

Over the past several decades, the prevalence of obesity has increased in epidemic proportions, particularly in developed and developing countries¹, such as Indonesia that has encountered double burdens of malnutrition. According to data of basic health research (Riskesdas), the prevalence of underweight in adolescents (13-15 years old) decreases from 11.1% in 2013 to 8.7% in 2018, and 9.4% in adolescents 16-18 years old in 2013 to decreases by 1.3% in 2018.^{2,3} On the other hand, the prevalence of overweight and

obesity in adolescents tends to increase in the last five years. In East Java province, the prevalence of adolescent malnutrition is 7.9% for underweight, 11.3% for overweight and 5.1% obesity.³ During adolescent period, obesity leads to metabolic syndrome including obesity in adulthood period, and increases cardiovascular diseases, which enhance premature death.⁴ In addition, adolescent girls have higher risk to suffer obesity than adolescent boys.⁵

Eating habits including food choice are responsible for malnutrition problem in Indonesia.⁶ For

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example, fast foods are very popular in adolescent life, especially who lives in urban areas. Those foods are prepared by using high temperature like broiled, grilled, roasted or fried, which result in increase of Advanced Glycation End products (AGEs).⁷ Consumption of those foods for a long time can cause human cell damages such as brain, lung, muscle and endothelial cells.⁸

Fiber and vitamin C are micronutrients which are required by the human body. Daily intake of fiber will increase satiety and reduce absorption of macronutrients such as glucoses, amino acids and fatty acids⁹, so that the risk of obesity can be reduced to smaller degrees.¹⁰ Additionally, adequate vitamin C intake helps the human body inhibiting oxidative stress, which generates from low grade inflammation of obesity.¹¹ In contrast, 96.4% Indonesian adolescents consume low fibers (<5 servings per day) and vitamin C, which are derived from fruits and vegetables.² Therefore, it is not surprised that the prevalence of adolescent obesity in Indonesia is high.

The objective of this research study was to analyze the relationship of daily intake of AGEs, fibers and vitamin C with respect to nutrition status in adolescent girls.

Materials and Methods

This cross sectional study was conducted in three state senior high schools (SMAN) in Kediri city, East Java from February to March 2019. Human subjects in this study were 150 adolescent girls who were in grade X and XI from those schools, and they were selected using stratified random sampling. Selected human subjects were eligible to follow this study if they were healthy and not fasting and already signed informed consent under approval of their parents/guardian. The protocol of this study has been approved by the Ethics Committee of Medical Research, Faculty of Medicine, Universitas Sebelas Maret with number 265/UN27.06/KEPK/EC/2019.

Nutrition status of human subjects was determined using body mass index (BMI) for age, based on the z-score issued by the Indonesian Ministry of Health (2010). Their nutrition status was classified into < -3 Standard Deviation (SD) for underweight, -2 SD - < 1 SD (normal weight), > 1 SD - 2 SD (overweight) and > 2 SD (obesity). Data of AGEs, fibers and vitamin C intake were obtained from 2x24 hours food recall questionnaires, which were then converted into daily intake using the previous study conducted by

Uribarriet *al.*⁷ for AGEs and the Nutrisurvey software (nutrisurvey2007.axe) respectively.

Collected data of AGEs, fibers and vitamin C intake were presented as kU/day, g/day and mg/day respectively while basic characteristics of human subjects were presented as mean $\pm$ SD and or percentage. Daily intake of fibers and vitamin C was then compared to the Indonesian Recommended Dietary Allowance (RDA). The Chi square test was used to analyze the relationship between daily intake of AGEs, fibers and vitamin C and nutrition status. Meanwhile data analysis of all variables used the multiple logistic regression test with 5% significant value.

Results

This cross sectional study was conducted in 150 adolescent girls who came from SMAN 3, SMAN 6 and SMAN 7 in the Kediri city. Table 1 showed that the mean age of selected human subjects was 15.91 ± 0.69 years old, and 70.7% among them aged 16-18 years old. The number of adolescent girls who were in grade X was similar to the number of adolescent girls from grade XI. Furthermore, they had low intake of AGEs, fibers and vitamin C (57.3%, 65.3% and 74.7% respectively). The mean daily intake of fibers and vitamin C was lower than that of RDA for adolescent girls. Normal nutritional status was observed in 74% adolescent girls whilst overweight and obesity were 16.7% and 9.3% among adolescent girls respectively.

Table 1: Characteristics of adolescent girls who participated in this study

Characteristics	Mean $\pm$ SD	Frequency (%)
Ages (years)	15.91 $\pm$ 0.69	
13-15		44(29.3)
16-18		106(70.7)
Class		
X		87(58.0)
XI		63(42.0)
AGEs intake (kU)	6,459.88 $\pm$ 3,880.61	
Low (<6,459.88 kU)		86 (57.3)
High ($\geq$ 6,459.88 kU)		64 (42.7)
Fiber intake (g)	5.65 $\pm$ 3.33	
High ($\geq$ 5.65g)		52 (34.7)
Low (<5.65g)		98 (65.3)
% RDA	18.87 $\pm$ 11.10	
Vitamin C intake (mg)	39.45 $\pm$ 67.4	
High ($\geq$ 39.45mg)		38 (25.3)
Low (<39.45mg)		112 (74.7)
% RDA	55.14 $\pm$ 96.83	
Height (cm)	154.610 $\pm$ 5.33	
Weight (kg)	52.670 $\pm$ 11.51	
BMI for age (kg/m²)	22.05 $\pm$ 4.53	
Nutrition Status		
Normal		111 (74.0)
Overweight		25 (16.7)
Obesity		14 (9.3)

To further investigate whether or not daily intake of AGEs, fibers and vitamin C was related to nutritional status among adolescent girls, the chi square test was used to analyze them. Table 2 indicated that positive relationships were found in all variables but it did not reach significantly. Higher daily intake of AGEs increased 1.85 times of obesity, compared to lower daily intake of AGEs (95% CI= 0.88-3.85; $p=0.101$). In contrast to daily intake of AGEs, higher daily intake fibers and vitamin C had lower risk of obesity, compared to lower daily intake of fibers (OR=0.92; 95% CI=0.43-1.99; $p=0.839$) and vitamin C (OR=0.85; 95% CI= 0.36-1.99; $p=0.710$).

Table 2: Relationship of AGEs, fibers and vitamin C daily intake with nutrition status among adolescent girls

	Nutrition Status		OR (95% CI)	p
	Normal n (%)	Overweight & Obesity n (%)		
AGEs intake				
<6,459.88 kU	68(45.3)	18(12.0)	1.85(0.88-3.85)	0.101
≥6,459.88 kU	43(28.7)	21(14.0)		
Fiber intake				
< 5.65g	72(48.0)	26(17.3)	0.92(0.43-1.99)	0.839
≥ 5.65g	39(26.0)	13(8.7)		
Vitamin C intake				
< 39.45mg	82(54.7)	30(20.0)	0.85(0.36-1.99)	0.710
≥ 39.45mg	29(19.3)	9(6.0)		

The multiple logistic regression test was used to analyze together daily intake of AGEs, fibers and vitamin C and their relationships with nutritional status after adjustment with age as a confounding factor (Table 3). These results were consistent with the results of bivariate analysis. Higher risk of obesity was observed in adolescent girls who consumed higher daily intake of AGEs than that of consumed lower daily intake of AGEs but it was not statistically significant ($p=0.104$). In addition, lower daily intake of fiber increased 0.85 times of obesity, compared to higher daily intake of vitamin C, but it was not statistically significant ($p=0.027$). All those variables were only contributed around 3% to nutritional status.

Table 3: Results of multivariate analysis between daily intake of AGEs, fibers and vitamin C and nutritional status among adolescent girls

	OR (95% CI)	p	Nagelkerke R Square
Model 1			
AGEs intake (High)	1.85 (0.88-3.89)	0.105	0.032
Fiber intake (Low)	0.88 (0.40-1.92)	0.747	
Vitamin C intake (Low)	0.92 (0.38-2.18)	0.845	
Model 2			
Age	0.76 (0.34-1.69)	0.504	0.027
AGEs intake (High)	1.85 (0.88-3.99)	0.104	
Fiber intake (Low)	0.85 (0.39-1.88)	0.700	
Vitamin C intake (Low)	0.92 (0.38-2.19)	0.845	

Discussion

In this present study, we have documented that the prevalence of obesity in adolescent girls in the Kediri city is 26%, in which 16.7% is overweight and 9.3% for obesity. We have also found that higher AGEs daily intake and lower fiber or vitamin C daily intake increase higher risk of obesity among adolescent girls, compared to lower AGEs daily intake and higher fiber or vitamin C daily intake in adolescent girls. The prevalence of this present study are greater than the prevalence of overweight of adolescent girls aged 16-18 years in East Java, based on Riskesdas' study (2018)³ which is 11.4% for overweight and 4.5% for obese. The results of this study are in line with the study conducted by Casagrande *et al.*¹³ which reported a similar prevalence of overweight and obesity among adolescents in Brazil.

The high prevalence of obesity among adolescent girls in Kediri city is related to higher daily intake of AGEs and lower daily intake of fibers and vitamin C. There are several reasons why these findings do not reach significantly. At first, the proportion of AGEs intake in adolescent girls is similar between lower and higher intake of AGEs. Secondly, the majority of adolescent girls has low daily intake of fibers and vitamin C. Thirdly, there is no cut off point of AGEs consumption that can lead to overweight or obesity so that we only used the subject's average daily intake for comparison. Fourthly, adolescent girls with normal nutritional status have higher daily intake of AGEs than adolescent girls with overweight or obesity. Therefore, we have to recruit a large number of adolescent girls in order to reach statistically significance. In this present study, however, we could not perform it because we have limited time and financial support.

A previous study has indicated that high AGEs intake can increase obesity, due to chronic accumulation of AGEs in adipose tissues. Adipocytes subsequently have big size and increase their cell numbers.¹⁴ The high percentage of AGEs consumption in this present study is in accordance with a previous study conducted in New York city. In this study there were 14.0% of overweight or obese girls having AGEs $\geq$ 6,459.88 kU, the average daily intake is lower than the average daily intake of healthy adults in New York, which is 17,500 kU/day.¹⁵ 48.0% of adolescent girls with normal nutritional status had a daily fiber intake of 5.65g, on the other hand, 17.3% of overweight and obese girls had a daily fiber intake of 5.65g. This study is in line with research findings by Azrimaidaliza¹⁶ which showed that fiber intake is lacking in adolescents who are overweight or obese. In this study it was found that the average daily intake of fiber for adolescent girls only reached 18.87% of RDA. This is also evidenced from the results of a survey of daily consumption of vegetables and fruits of Indonesian people aged 13-18 years which were 98.4% less than the RDA.¹⁷ The weak strength of the correlation between fiber and nutritional status in this study might be due to the lower daily fiber intake compared to the RDA on average.

Low intake of micronutrients other than fiber in this study was also found in vitamin C intake in the majority of adolescent girls with normal nutritional status or overweight and obese. The average intake of vitamin C in adolescent girls in this study was still less than the RDA (55% RDA). This study is in line with previous study conducted by Sholicha and Muniroh (2019).¹⁸ which found that the intake of vitamin C for high school girls in Gresik was relatively low at 29.1 ± 27.3 g / day (42.2% RDA). Previous research conducted by Faraget *al.* (2019)¹⁹ found that vitamin C supplementation (500 mg/day) could

significantly reduce BMI in obese adults. But in this study there was no significant relationship between daily intake of vitamin C in adolescent girls with nutritional status. This could be due to the small number of subjects.

Conclusion

This study concludes that there is high prevalence of overweight and obesity of adolescent girls in Kediri city. Most adolescent girls have low daily intake of Advance Glycation End products, fibers and vitamin C. High AGEs intake and low intake of fiber and vitamin C increases risk of overweight and obesity in adolescent girls in Kediri city, however it is not found statistically significant. Nutrition education needs to be done to improve fiber and vitamin C intake, and reduce AGEs intake to reduce overweight and obesity prevalence.

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Ethical Approval

The protocol of this study has been approved by the Ethics Committee of Medical Research, Faculty of Medicine, Universitas Sebelas Maret with number 265/UN27.06/KEPK/EC/2019.

Conflict Interest

None declared.

Author's Contributions:

Data gathering and idea owner of this study: RMS, DI

Study design: RMS, DI

Data gathering: RMS

Data analysis and consultation: DI, DH

Writing and submitting manuscript: DI, DH

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