A cross-sectional study of vitamin A, C and D and Iron daily intake among adolescents and its correlation with over nutrition status

M A M Putri, D Indarto, and V Widyaningsih

1Postgraduate of Nutrition Sciences, Universitas Sebelas Maret, Surakarta
2Postgraduate Student of Human Nutrition Sciences, Universitas Sebelas Maret, Surakarta
3Department of Physiology, Faculty of Medicine, Universitas Sebelas Maret, Surakarta
4Biomedical Laboratory, Faculty of Medicine, Universitas Sebelas Maret, Surakarta
5Department of Public Health and Preventive Medicine, Faculty of Medicine, Universitas Sebelas Maret, Surakarta

*dono@staff.uns.ac.id

Abstract. Obesity in adolescents has significantly increased in the last ten years, characterized by high consumption of unhealthy diet such as drinking sugar sweetened beverages and eating fast foods. Such foods contain high carbohydrates, high saturated fats, low fibers and low micronutrients like vitamin A, C, and D, and Fe. Therefore, this study aimed to investigate the correlation of daily micronutrients intake and over-nutrition status in adolescents. This cross-sectional study was conducted in 45 adolescents with over nutrition in Surakarta city. Data of daily vitamin A, C, and D and Fe were collected using a 24 hours’ food recall questionnaire, which was then converted using a free NutriSurvey software whilst over nutrition status was determined using the World Health Organization Anthro chart. To assess the correlation of individual variable with over-nutrition status, the Rank Spearman test was used and the multiple linear regression test was used to analyze all together variables with over-nutrition status. Daily intake of Vitamin A (r = 0.052; p = 0.736), vitamin C (r = 0.113; p = 0.459), and Fe (r = 0.106; p = 0.487) were not correlated with over-nutrition status but vitamin D intake significantly correlated with over-nutrition status (r = -0.410; p = 0.005). In conclusion, daily micronutrients intake has different correlations with over-nutrition status among adolescents.

1. Introduction

Over-nutrition has become a global problem in the last two decades [1]. Previously, over-nutrition commonly occurred in developed countries, but now it has been increasing sharply in developing countries [2]. In Asia, the prevalence of overweight and obese adolescents are higher in males than in females [3]. Data of Basic Health Research in Indonesia show that overweight prevalence in 16-18 years old increases from 5.7 % in 2013 to 9.5 % in 2018. Meanwhile, obesity prevalence of the same age increases almost double in 2018 (4%), compared with the prevalence in 2013. The increased prevalence of overweight and obesity also occurred in Central Java Province with the same pattern but the number is slightly lower than those national numbers [4].
Over-nutrition in adolescents is influenced by several factors such as unhealthy diet, sedentary lifestyle and low physical activity [5]. High consumption of sugar-sweetened beverages and fast foods that contain high carbohydrates and saturated fats and low fiber, vitamin and mineral is positively associated with obesity [6]. On the other hand, the consumption of fruits derived-vitamins and minerals is 30.1 g/day below from the Indonesian dietary recommendation and 37.9 g/day in Central Java [7,8]. Whereas WHO recommends daily consumption of fruits and vegetables at least 400 g, consisting of 250 g vegetables and 150 g fruit [9]. Another study reported that people with overweight and obesity have lower daily intake of vitamins A, C, and D, and fiber, compared to individuals with normal nutritional status [10].

In addition, deficiencies of antioxidants, vitamins and minerals inversely correlate with serum leptin levels which increase lipid storage in adipose tissues and inflammatory response [11]. For this reason, this study aimed to evaluate vitamin A, C and D and iron daily intake among adolescents and its correlation with over-nutrition status.

2. Methodology
This was a cross sectional research study with purposive sampling method was conducted in 45 overweight and obese adolescents who aged 15-18 years old and were from three Senior High Schools in Surakarta. This research protocol has been approved by the Health Research Ethics Committee (KEPK), Faculty of Medicine, Universitas Sebelas Maret, Surakarta (No.042 / UN27.06.6.1 / KEPK / EC / 2020). Before collecting data, all selected students agreed to participate to this study by signing the informed consent under their parent supervision. Anthropometric data of those students were obtained from their body weight in kg and height in m whilst and over nutrition status was determined using the World Health Organization Anthro chart. Twenty four-hour food recall and International Physical Activity Questionnaires were used to collect daily nutrients intake and physical activities respectively. Data of daily intake of vitamins A, C, and D, and iron were then converted using a free Nutrisurvey software.

All collected data were processed and analyzed using version 25 the Statistical Package for Social Sciences (SPSS) program. Numerical and categorical data were presented as mean ± standard deviation and frequency, followed by percentage. Before performing individual correlation of research variables using the Spearman Rank test, data normality was verified using the Shapiro Wilk test. The results of bivariate analysis with p < 0.25 were further analyzed using the multiple linear regression test and a significance value was set up < 0.05.

3. Result and Discussion
Table 1 showed that research respondents were dominated by females (62.2%) with mean age of 16.2 ± 0.72 (range 15-18 years old). Research respondents with overweight (77.8%) were higher than that of obesity (22.2%), which 75.5% among them had low physical activity levels. Surprisingly, more research respondents brought ≤ 15,000 IDR pocket money during school days. Almost 50% their parents graduated from senior/vocational high Schools. Inadequate micronutrients intake was found in most respondents, which vitamin D deficiency appeared in all respondents.

| Variable                  | Total (n: 42) % | Mean ± SD     |
|---------------------------|----------------|---------------|
| Gender                    |                |               |
| Female                    | 28 (62.2)      | 1.37 ± 0.49   |
| Male                      | 17 (37.8)      |               |
| Age                       |                |               |
| 15 years old              | 4 (8.9)        |               |
| 16 years old              | 27 (60.0)      | 16.2 ± 0.72   |
| 17 years old              | 11 (24.4)      |               |
| 18 years old              | 3 (6.7)        |               |
| Status Gizi (BMI/age)     |                | 1.77 ± 0.54   |
Overweight 35 (77.8)
Obese 10 (22.2)

**Physical Activity**
Low 34 (75.5)
Moderate 7 (15.6)
High 4 (8.9)

**Pocket Money**
≤ 15,000 IDR 32 (71.2)
> 15,000 IDR 13 (28.8)

**Father Education**
Elementary school 1 (2.2)
Junior high school 8 (17.8)
Senior high school/ vocational 21 (46.7)
University 15 (33.3)

**Mother Education**
Elementary school 3 (6.7)
Junior high school 7 (15.6)
Senior high school/ vocational 21 (46.7)
University 14 (31.1)

**Vitamin A (IU/day)**
Inadequate 30 (66.7)
Adequate 15 (33.3)

**Vitamin C (mg/day)**
Inadequate 37 (82.2)
Adequate 8 (17.8)

**Vitamin D (mcg/day)**
Inadequate 45 (100)
Adequate 0 (0)

**Iron (mg/day)**
Inadequate 37 (82.2)
Adequate 8 (17.8)

In order to know the correlation of vitamins A, C, and D, iron daily intake and its confounding factors with over-nutrition, we analyzed using the Spearman test. In general, the daily intake of vitamins and iron and its confounding factors had moderate or low correlation (Table 2). Vitamin D intake ($r = -0.410; p = 0.005$) and physical activity ($r = -0.031; p = 0.039$) negatively correlated with over-nutrition and reached significantly.

**Table 2.** Correlation of Vitamin A, C, and D, Iron Daily Intake and Confounding Factors with Over-nutrition

| Variable        | Min   | Max    | Mean ± SD         | r     | p       |
|-----------------|-------|--------|-------------------|-------|---------|
| Vitamin A       | 357.90| 4,728.5| 1,486.88 ± 818.41 | 0.052 | 0.736   |
| Vitamin C       | 2.35  | 212.7  | 38.73 ± 46.08     | 0.113 | 0.459   |
| Vitamin D       | 0.00  | 4.10   | 0.851 ± 0.830     | -     | 0.005   |
| Iron            | 3.30  | 17.5   | 7.12 ± 3.22       | 0.106 | 0.487   |
| Age             | 15    | 18     | 16.29 ± 0.73      | -     | 0.905   |
| Physical Activity| 49.5  | 2160   | 477.79 ± 560.54   | -     | 0.039   |
| Pocket Money    | 5,000 | 40,000 | 14877.7 ± 7030.1  | 0.131 | 0.392   |

Because vitamin D intake and physical activity had $p < 0.25$, we further analyzed using the multiple linear regression test. Table 3 indicated that vitamin D intake and physical activity inversely correlated with over-nutrition with $p < 0.001$. After adjusting with physical activity as a confounding
factor, the correlation coefficient of vitamin D intake was lower than the correlation coefficient of vitamin D intake using bivariate analysis but it is still significant with \( p = 0.008 \).

| Table 3. Regression Linear Analysis of Vitamin D Intake and Physical Activity with Over-nutrition |
|-----------------------------------------------|
| Variable | \( b^* \) | \( t \) | sig | \( \beta^{**} \) |
|---|---|---|---|---|
| Vitamin D | -0.261 | -2.767 | 0.008 | -0.395 |
| Physical Activity | -4.732 | -0.338 | 0.737 | -0.048 |

R square = 0.154  
\( P \) (sig) = 0.000  
n observations = 45  
\( b^* \) = Unstandardized coefficients  
\( \beta^{**} \) = Standardized coefficients

4. Discussion

In this study, we found only low consumption of vitamin D inversely correlated with over-nutrition among adolescents in Surakarta city. Over-nutrition is defined as the accumulation of fat in the body that exceeds the normal amount due to an imbalance of nutrients so that it can increase the risk of health problems [12]. Micronutrients are vitamins and minerals that the body needs in small amounts for optimal growth and development and physiological function [13,14]. From our findings, it showed that most respondents had low daily intake of vitamins A, C, and D, and iron less than from the recommended dietary allowance (Table 1). The results of this study is in line to Agarwal et al. study that individuals with overweight and obese have lower intake of vitamins A, C, and D than individuals with normal nutritional status [10].

Vitamin A has an important role in lipid metabolism and insulin response by interacting with retinoic acid receptors (RAR) and \( \beta / \delta \) peroxisome proliferators (PPAR\( \beta / \delta \)). Low vitamin A intake disrupts lipid metabolism and increases insulin resistance [15, 16]. Inadequate intake of vitamin A in our respondents may be caused by insufficient consumptions of vegetables, fruit and nuts [17]. However, the results of the Spearman correlation test showed that vitamin A intake was not correlated with over-nutritional status. Similar findings in Krizek et al. study showed that vitamin A intake was not correlated with BMI in obese respondents [18]. Previous research in Mexico and China showed vitamin A have a positive correlation with obesity. However, this is only found in individuals with BMI <30. It is different with individuals with a higher BMI and body fat where the concentration of vitamin A is positively correlated to triglycerides and total cholesterol [19, 20].

In this study, vitamin A was not related to over-nutrition status maybe because the majority of respondents were overweight (77.8%) (Table 1). Thus, no correlation was found between vitamin A intake and over-nutrition status. Vitamin C has been linked to obesity through several mechanisms. If intake of vitamin C low, it can affect the modulation of lipid accumulation, inhibit lipolysis and inhibit glucocorticoid production [21]. In this study, it was found that 82.2% of over nutrition adolescents had a vitamin C intake below the recommendation. However, the results of the Spearman correlation test showed that vitamin C intake was not correlated with over-nutrition status. The same thing was found in the study of Larsen et al. showing that there was no correlation between vitamin C intake and body weight and waist circumference [22].

In contrast to the research, Garcia et al showed that low vitamin C concentrations are associated with high body fat in obese individuals [19]. In this study, the measurement of vitamin C was limited only by collecting food intake data. On the other, the content of vitamin C in food really depends on how it is stored and processed. So that a lack of data accuracy can occur. Therefore, measurement of blood samples to see serum concentrations can strengthen the results of future studies.

Vitamin D is a micronutrient that the body needs to maintain blood levels of calcium and phosphate which will be needed for bone mineralization, muscle contraction, cellular function, and nerve conduction [23]. Currently, various studies report that vitamin D deficiency has an effect on increasing
nutritional status [24, 25, 26]. In this study, it was found that all respondents had inadequate intake of vitamin D. Based on food intake data, the variety and amount of food sources of vitamin D consumed is still lacking. Whereas food sources of vitamin D are mostly obtained from fish, meat, eggs, mushrooms and milk [27, 28].

The results of the correlation test using Spearman showed that vitamin D intake had a negative correlation with nutritional status in over-nutrition adolescents. This means that the lower intake of vitamin D, the higher increase in nutritional status. Similar findings in the study of Grineva et al. showed that vitamin D deficiency is at risk of obesity and insulin resistance which will lead to diabetes mellitus type 2 [29]. Vitamin D plays a role in obesity through several mechanisms such as the expression of oxidative stress proteins, inflammation and cell metabolism [30]. Vitamin D will be converted into an active form namely calcitriol. Calcitriol has a role in human adipose tissue by modulating adipokine expression, inhibiting anti-inflammatory cytokine expression, reducing monocyte recruitment by pre-adipocytes, and increasing insulin-stimulated glucose uptake [31].

Iron deficiency often occurs in individuals with over-nutrition [32]. In over-nutrition conditions, the accumulation of fat in the adipose increases, causing low grade inflammation. Inflammatory cytokines, namely TNF-α and IL-6, will increase and trigger the release of hepcidin in obesity. Hepcidin will reduce iron transport, reduce iron absorption, and prevent iron mobilization [33, 34, 35]. The prevalence of iron deficiency or hypoferremia was found to be higher in overweight and obese individuals compared to normal nutritional status [36]. In this study, it was found that 82.2% of over-nutrition adolescents had iron intake below the recommendation. However, the results of the Spearman correlation test showed that iron intake was not correlated with the incidence of over-nutrition. Similar findings in the study of Sal et al. showed that there is no relationship between iron deficiency in obese patients [37].

5. Conclusion
Daily micronutrients intake has different correlation with over-nutrition among adolescents but only vitamin D inversely correlates with over-nutrition after adjusting with physical activity. In future study, it will require more adolescents involved in this study and also investigate other factors that affect over-nutrition.

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