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Original Article

Nutritional Intake and Oxygen Saturation in Adolescent Girls in Central Java, Indonesia

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ABSTRACT

Background: Adolescents are usually thought of having a healthy condition, so study about their physical health, especially that related to lung condition is very limited. Indicator used for assessing lung condition is oxygen saturation. The study aimed to analyze the association of nutritional impact to oxygen saturation in adolescent girls in Central Java, Indonesia.

Methods: This study used a cross-sectional design with 378 adolescent girls in Central Java, Indonesia as respondents. To find which nutrition intake related to oxygen saturation, data of each nutrition intake and SpO_2 level were analyzed using linear regression. Data of body mass index, hemoglobin level and upper arm circumference were also included in the analysis since previous research showed their correlation with oxygen saturation.

Results: The prevalence of low SpO_2 in adolescents is 8.5%. The nutrition intake which significantly related to oxygen saturation were fat (p = 0.007; CI = -0.021, -0.003) and vitamin D (p = 0.037; CI = 0.005, 0.172).

Conclusions: Adolescents should decrease fat consumption, increase vitamin D consumption, and need to increase arm circumference by consuming more protein and living a healthy lifestyle to avoid infectious diseases.

Keywords: *Body Mass Index, Vitamin D, Oxygen Saturation*

INTRODUCTION

Adolescence is a transition period from child to adult. At this period, moreover for girls who will become mothers later, preparing a healthy body is important so that they need to understand their own physical health starting from this phase of life. One indicator showing a healthy person is blood oxygen saturation (SpO_2). Blood oxygen saturation (SpO_2) is related to respiratory and circulation system condition; as one of indicators of a healthy lung [1]. The ideal number of SpO_2 is over 95%, moreover for young age normal oxygen saturation is good to be between 97-100% [2]. The change of SpO2 below 95% means someone is in a condition of hypoxia (low level of oxygen saturation).

Adolescents are usually thought of having a healthy condition, so study about their physical health, especially that related to lung condition is very limited. Adolescents or specifically girls would mature then and get pregnant when they are sexually active or get married. This SpO_2 measurement could predict adverse maternal outcomes such as maternal mortality and serious morbidity [3]. Low oxygen saturation condition prevalence in adolescents remains unknown, however previous study showed that hypoxia prevalence was between 6.3% and 8.6% in healthy population, while obesity, chronic diseases (asthma, COPD, cardiovascular diseases, hypertension and diabetes) and having lung symptoms as factors related to such condition [4,5]. It is also related to hemoglobin levels in the blood because oxygen from the lungs to the body's tissues is carried by hemoglobin contained in erythrocytes.

Hypoxia could affect other organ conditions and also be related to energy intake and appetite [6], so adolescent girls should manage it because they still need much nutrition for

their growth. Adequate intake of macronutrients and micronutrients is also needed for the immune system, so individuals can be more protected from infectious diseases [7]. Previous research was conducted on mountaineers, while research on adolescent girls has never been conducted, therefore this study aimed to describe prevalence of low SpO_2 in adolescent girls who are not familiar with such chronic diseases and whether their nutritional intake is related to oxygen saturation (SpO_2).

METHODS

The study used samples of adolescent girls in Banyumas, Purbalingga and Kebumen District, Central Java, Indonesia. The sampling method was stratified-random sampling with three strata: public/private high school, vocational high school, and Islamic high school from every district. The eligible criteria of the study were adolescent girls aged 16-18 that presented at school during data collection and agreed to participate in the study confirmed by filling out written informed consent. The study has been authorized by the Medicine Faculty Ethics Committee, Universitas Jenderal Soedirman, with document no. 346/KEPK/X/2019.

The data collection was in November 2019. The questionnaire was a self-administered questionnaire with one guide reading the question and giving an explanation in front of the classroom. Respondents were asked to fill out their demographic characteristics and food frequency for the last month to measure their nutritional intake. SpO_2 levels were measured using a digital handheld pulse oximeter. Besides SpO_2, hemoglobin levels were also measured using a digital hemoglobin meter. Respondents' height and weight were measured using microtoise and digital weight scales. The upper arm circumference was also measured using tape.

Statistical analysis used for the study was linear regression. To minimize the bias, respondents with SpO_2 level under 70% were excluded in the analysis, and then the remaining samples were used to describe the prevalence of low SpO_2 in adolescent girls.

RESULTS

Based on the descriptive statistics, the prevalence of low SpO_2 level in adolescent girls is 8.5% (Figure 1). The average upper arm circumference in respondents with low level of SpO_2 is 23.3 (SD = 2.3) lower than in respondents with normal level of SpO2 which is 23.9 (SD = 2.5). The correlation test shows a significant correlation between upper arm circumference and SpO_2 level.

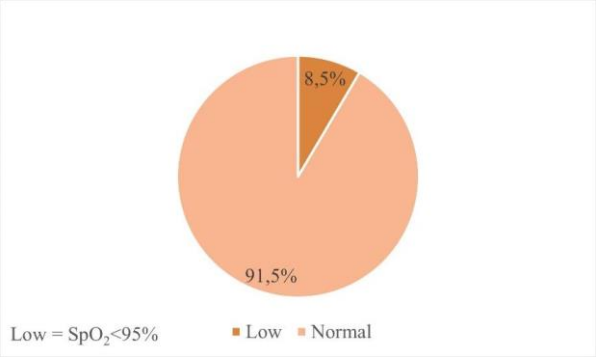

Figure 1 Prevalence of low SpO2 level in adolescent girls

Based on linear regression analysis, predictors of SpO_2 in adolescent girls are upper arm circumference, fat, and vitamin D. The coefficient of determination (R^2) for the model is 0.029 means 2.9% variation of oxygen saturation can be described by the model. Related to multivariate model assumption, the model has met all the assumptions.

Table 1 Adolescent girls' characteristics and its correlation with SpO_2 level

Characteristics	Low (≤95%) n=33 mean± SD (range)	Normal (>95%) n=355 mean± SD (range)	Coefficient correlation
SpO_2	93± 2.3 (86-95)	98± 1.2 (96-99)	1.000
Body mass index	20.1± 3.1 (14.6-29.9)	21.0± 3.5 (14.3-39.6)	0.096
Weight	49.5± 8.0 (37.1-70)	48.9± 8.9 (33.1-105.8)	0.004
Height	152.7± 5.2 (138.5-164)	153.0± 5.4 (137-176.7)	0.062
Hemoglobin level	13.6± 1.4 (10.8-16.1)	13.3± 1.5 (7.9-18.2)	-0.005
Upper arm circumference	23.3± 2.3 (19.5-29.8)	23.9± 2.5 (18.5-40.0)	0.120*

*p<0.05

Table 2 Adolescent girls' daily nutritional intake

Nutrition	mean ± SD (range)	Adequacy index*
Carbohydrate (g)	179 ± 102 (35-930)	300
Protein (g)	50 ± 39 (6-287)	65
Fat (g)	37 ± 36 (1-259)	70
Iron (mg)	11 ± 10 (1-118)	15
Folic acid (µg)	224 ± 411 (15-5954)	400
Vitamin B12 (µ	2 ± 2 (0-21)	4
Vitamin D (µg)	2 ± 4 (0-37)	15

*BMI reference = 20.6; BMI samples = 20.9

Table 3. Results of linear regression to explore nutritional intake related to SpO_2 level

Predictors	B	(95% CI)	p
(Constant)	95.861	(93.935, 97.788)	<0.0001
Upper arm circumference	0.083	(0.003, 0.162)	0.043
Fat	-0.012	(-0.021, -0.003)	0.007
Vitamin D	0.089	(0.005, 0.172)	0.037

Table 4. Multivariate model assumptions

Assumption	Testing Result
Independency	Durbin-Watson = 1.853
Linearity	p (Anova) 0.011
Homoscedasticity	Scatter plot shows no pattern
Normality	Histogram shows normal distribution and normal P-P plot shows residual distribution near diagonal line
Collinearity	VIF < 2.6

DISCUSSION

This study showed that the percentage of low SpO_2 in adolescent girls was 8.5% at second data collection. This prevalence is higher than previous research that showed the prevalence of low SpO2 level for people age <65 years was 5.2% [4]. Measuring SpO_2 is very sensitive to altitude [8]. The study was conducted in Banyumas with altitude 200-1500 m, Purbalingga 55 m, and Kebumen 0-737 m [9], Central Java, where the SpO_2 cut-off should not have significant difference.

According to a descriptive analysis, adolescent girls' nutritional intake per day is less than the nutritional adequacy index suggested by the Health Ministry of Indonesia [10]. As mentioned in Table 2 that all micro and macro nutrients, such as carbohydrate (179 g < 300 g), protein (50 g < 65 g), fat (37 g < 70 g), iron (11 mg < 15 mg), folic acid (224 µg < 400 µg), vitamin B12 (2 µg < 4 µg) and vitamin D (2 µg < 15 µg) are not consumed by adolescent girls at their enough amount. Especially for carbohydrates, fat, folic acid and vitamin D the daily intake is much lower than the suggested index. Adolescents whose daily nutrient consumption is lower than the standard occurs due to eating less than three meals a day [11], have low food and nutrition literacy [12], and low dietary diversity [13].

The study showed that every gram of fat consumption caused 0.012 SpO_2 reduction. Fat is beneficial as a source of energy and has more calories than carbohydrate (9:5), besides those are vitamin A, D, E and K as fat-soluble vitamins which have functions for the body. Vitamin A is beneficial for vision health [14], vitamin D is for bone health [15] that in this study showed correlation with oxygen saturation that its explanation will be discussed later, vitamin E is for antioxidant [16] and vitamin K is related to blood clotting process [17]. Those are the reasons why adequate consumption of fat is beneficial to maintain organ systems' working stability. But fat also has various types which have different effects for the body. The fat that is good for the body is unsaturated fat which can increase HDL and decrease LDL in blood, so heart health and blood circulation could be maintained. Fat that is bad for the body is trans-fat, while fat that is dangerous if it is consumed too much is saturated fat that could increase LDL in blood. In this study, the common source of fat consumed by adolescent girls are fried chicken, chicken egg, sausage and milk which are saturated fat. Based on nutritional adequacy figures, female adolescents aged 16-18 need approximately 70 grams of fat. If teenagers consume more, the excess fat could accumulate in the neck area resulting in a narrow upper airway so that the volume of air entering the lungs becomes less [18]. Fat can also accumulate in blood vessels so that blood circulation becomes uneventful [19,20]. This condition results in decreased oxygen levels in the blood. This study showed that every gram increase in fat consumption would result in a decrease in SpO_2 by 0.012. If we assume a decrease from the maximum SpO_2 value of 100 and the condition of low oxygen saturation is 95, then the decrease of 5 is equivalent to fat consumption of 417 grams of fat. If in a day the teenager has the habit of drinking a glass of milk brewed from three tablespoons of powdered milk or consuming sausages up to ten pieces per day, it will increase the buildup of saturated fat in the body. If adolescents experience extreme SpO_2 decline, adolescents could have oxygen tube [21], but the treatment is unlikely to be given forever because it will certainly interfere with adolescent activity and require no small cost. Therefore, adolescents are advised to reduce fat consumption, including consuming low-fat milk, or replacing the habit by consuming unsaturated fats.

The study also showed that vitamin D consumption is correlated with SpO_2. Vitamin D is one of the micronutrients needed by the body. Since its discovery, many studies have been conducted to see the link of vitamin D with several diseases, including musculoskeletal, cancer, cardiovascular, autoimmune, neurological disorders, pregnancy disorders, and respiratory infections [22]. In this study, the link of vitamin D consumption with SpO_2 further leads to the role of vitamin D in protecting the respiratory organs from infection. When adolescent girls are deficient in vitamin D consumption (less than 15 µg or 600 IU per day), the risk of infection will increase. The results showed that vitamin D consumption as much as 1 µg can increase SpO_2 levels by 0.089 or in other words, when a person decreases SpO_2 levels to 95, to increase it to 100 required consumption of vitamin D as much as 57 µg or 2280 IU. Thus, in conditions of low SpO_2 levels, adolescents need to consume two to three tablets of vitamin D supplements. Meanwhile, under normal conditions, to meet the daily needs of vitamin D, adolescents can consume foods containing vitamin D. In this study, the food ingredients that have the highest source of vitamin D consumed by teenagers are powdered milk, chicken eggs, fresh milk, and mushrooms. In the adolescents' daily consumption in this study, milk powder had the highest vitamin D content. If adolescents consume three tablespoons of powdered milk, adolescents will be able to meet their daily vitamin D needs. In line with the correlation between fat and SpO_2, to overcome excess fat consumption, vitamin D needs can be fulfilled, adolescents can replace

powdered milk with low-fat milk. Adolescents can also consume up to seven to eight eggs per day, especially the yolk because the egg whites in chicken eggs do not contain vitamin D [23]. However, some studies show excess egg consumption can increase the risk of heart disease because eggs also contain fat where the fat content in the yolk is higher than the egg white (1:90). The risk of fat accumulation in the body can be overcome by reducing carbohydrate consumption so that the body will convert excess fat into energy or by consuming green tea two hours after having a meal so that the fat oxidation process will increase [24]. Aside from food, vitamin D can also be obtained through sunlight so that increasing activities outside the home can also be done.

Upper arm circumference is an indicator used to measure nutritional status which is a manifestation of long-term (chronic) malnutrition that describes how calorie intake is primarily related to macronutrients, namely protein: an important nutrient in the process of regeneration of damaged cells. A condition of malnutrition is associated with infectious diseases [25]. If the infection occurs in organs in the respiratory system, this will have an impact on the quality of the respiration process so that oxygen saturation in the blood will decrease (low SpO_2). In addition to upper arm circumference, BMI can also be used to measure nutritional status, but BMI is usually more volatile compared to upper arm circumference which is relatively more stable. Nonetheless, generally a person's upper arm circumference is correlated with his BMI.

This study has limitations in measuring calorie intake using food frequency questionnaires and meal portions for the past one month so that it is susceptible to recall bias. In addition, oxygen saturation measurements were carried out using an oximeter, while the most valid oxygen saturation measurement is by using a blood gas analysis examination. However, this study can be a reference for further research using more valid instruments and longitudinal study designs. The research samples have BMI mean of normal nutritional status, so further research to understand the phenomena using other categories of nutritional status would be beneficial to enrich the understanding of correlation between nutritional intake and oxygen saturation.

CONCLUSIONS (Arial Narrow Font 11, Bold)

Based on the results of this study, the nutritional intake related to SpO_2 levels is fat and vitamin D, so adolescent girls need to increase their intake of fat and vitamin D. Upper arm circumference is also related to SpO_2 levels where this is related to protein intake. Food example that can be recommended is eggs, especially the yolk. Adolescent girls should also increase outdoor activities, especially in the morning and evening to increase exposure to sunlight. Further research using longitudinal design could also be conducted to increase adolescent girls' healthy status related to their nutritional intake.

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