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# Determinant factors of obesity in urban and rural studies on adolescents in Banten Province, Indonesia

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**ABSTRACT**

**Background:** The prevalence of obesity which continues to grow in children and adolescents is a concern since it increases degenerative disease risk. Obesity is not only a problem in urban areas, but it is also growing in rural areas.

**Objective:** The aim of this study was to analyze the determinants of obesity in adolescents in rural and urban areas in Banten Province.

**Materials and Methods:** This research design used a case-control method with a purposive sampling technique. The sample in the study consisted of 160 adolescent subjects from 2 different schools. Each school representing 40 case samples that were adolescents with obesity and control adolescents with a normal body mass index. This study was conducted at one school in Cilegon City to represent the urban sample and one school in Pandeglang Regency to represent the rural sample. For each sample, body weight and height were measured, filling out the SQ-FFQ, International Physical Activity Questioner (IPAQ), Pittsburgh Sleep Quality Index and DASS-42 (Depression Anxiety Stress Scale) questionnaires. Data regarding the results of air quality monitoring which includes data (PM10, SO2 O3 and NO2) was obtained from the Environmental Service. Meanwhile, data were analyzed by using Chi-Square and logistic regression.

**Results:** The determinants of obesity in adolescents in rural were protein intake more than RDA (p=0.003 OR=9.948), low physical activity (P=0.005 OR=22.094), high of SO2 exposure (P=0.005 OR=19.817) and bad sleep quality (P=0.007 OR=8.901) while adolescents in urban were protein intake more than RDA (p=0.001 OR=21.570), bad sleep quality (p=0.002 OR=16.550), high stress level (p=0.006 OR=15.922) and carbohydrate intake more than RDA (p=0.072 OR=5.044).

**Conclusion:** Protein intake is the biggest determinant of the incidence of obesity in adolescents both in rural and urban areas.

***Keywords:*** *Obesity; Rural and Urban Areas; Adolescents*

## BACKGROUND

Obesity which occurs in adolescents and children is a problem that has emerged and has become an epidemic throughout the world. Its prevalence continues to increase in developing countries and the results are almost close to the prevalence rates in developed countries.[1] Indonesia is a developing country with a double burden of malnutrition due to the problems of obesity and malnutrition. Based on 2018 Riskesdas data, 16.6% of adolescents aged 13-15 years were obese.[2] It is predicted that in 2030 there will be around 9 million more children and adolescents aged 5-19 years who are obese in Indonesia.[1] An imbalance between diet and physical activity which occurs over time (chronic) leads to abnormal fat accumulation.[3] Adolescence marks a critical period of growth in the lifetimes because big changes in physical, cognitive and social development occur. Adolescent health is affected by childhood well-being and establishes a trajectory for adulthood health status.[4] Obesity in adolescents and children will reduce the level of health and become the root of development degenerative diseases which previously could only be identified in adulthood, but they are now also found at a very young age; such as, diabetes mellitus, hypertension, dyslipidemia and NAFLD (non-alcoholic fatty liver disease).[5]

Several determinant factors for obesity in adolescents are as follows: Individual factors include genetics, parental nutritional status, diet quality, physical activity, sleep quality and stress levels.[6–11] Socioeconomic factors including household income, parent's occupation, place of residence and parent's education.[12] Community factors, namely the school environment and literacy knowledge, environmental factors consist of exposure to air pollution and obesogenic environments.[13] In addition, based on research which had been conducted in China, exposure to air pollution over many years (long term exposure) was associated with increased body weight and the prevalence of obesity in children and adolescents.[14]

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Social demographic factor is considered as one thing which needs to be considered. Obesity is closely related to urban areas because high consumption of fast food and lower exercised.[12] Currently the incidence of obesity in adolescents living in rural areas has shifted to almost the same as in urban areas. However, there are differences in factors causing obesity between urban and rural cases.[15] Research conducted by Nurwanti stated that the difference is due to differences in food consumption patterns between teenagers living in rural and urban areas. Consumption of burnt food and salty foods is associated with the risk of being overweight in rural areas, while in urban areas consumption of caffeinated drinks and energy drinks.[16] Furthermore, an obesogenic environment is a differentiator between urban and rural areas, higher levels of exposure to air pollution in urban areas are an indicator of the cause of obesity.[17] Banten Province is one of the provinces in Indonesia which is located on the island of Java, consist of 4 cities and 4 regency in every region have a different characteristic. Cilegon is one of cities in Banten as known as major industrial city in Java also called "the City of Steel" because the biggest manufacturer that produce steel in Southeast Asian. High production activities from factories and transportation (become link between the islands of Java and Sumatra), that provoke high air pollution in Cilegon.[18] Pandeglang is regency in Banten which has regional characteristics that are very different from Cilegon. Most of the area consists of forests and plantations. Based on Riskesdas prevalence of adolescents aged 13-15 years in Banten who are obese in urban areas (10.59%) and in rural areas (7.8%).2 Because differences region in Banten. The aim of this study is to see what determinant factors cause obesity in urban and rural areas in Banten Province, Indonesia.

## MATERIALS AND METHODS

This study was an observational study by using the case control method. It was conducted from October to December 2023 in two junior high schools (SMP). Each school represented its demographic situation. The urban sample was represented by one school in Cilegon City and the rural sample was represented by one school in Pandeglang Regency. Moreover, determining the sample in this study used a purposive sampling. The criteria for being in the case group were adolescent with a BMI/Age value >+2 SD and the control group was adolescent with BMI/Age (-2SD)-(+1SD). Total sampling are 160 adolescent lived in Cilegon City and Pandeglang Regency who were aged 13 -15 years old who was in the second grade of Junior High School (SMP).

Adolescent nutritional status was measured by using a digital scale with an accuracy of 0.01kg in order to determine the adolescent's weight and a microtoise with an accuracy of 0.1 cm to determine the adolescent's height. Data collection on weight and height was conducted by adolescent without wearing shoes. Moreover, an analysis was conducted by using BMI/Age which was calculated based on specific gender and age. Then the results were categorized into the case group with BMI/Age values >+2 SD and the control group with values (-2SD)-(+1SD).[19] Data exposure PM10, $NO_2$, $SO_2$ and $O_3$ air pollution for the past year was obtained from the Cilegon City Environmental Service and the Pandeglang Regency Environmental Service. The data was grouped based on sampel residence. In addition, the average air pollution exposure concentration data for one year was then categorized by using a cut off median data value.[20]

Sleep quality and duration were measured by using the Pittsburgh Sleep Quality Index (PSQI) questionnaire. The data was grouped into 2 groups, that were the group with good sleep quality had a score of ≤5 and the group with poor sleep quality had a score of >5.21 The results of measuring sleep duration were divided into 2 groups, namely the group with insufficient sleep duration (sleep duration at night <8 hours) and the group with sufficient sleep duration (sleep duration at night was 8-10 hours).[22]

Nutrient intake data was obtained by using the SQ-FFQ questionnaire. The nutrient intake data analyzed by using the Nutrisurvey 2007 application. The results of nutritional intake (protein, fats, carbohydrates and fiber) were then analyzed with the total needs of each individual adjusted based on the gender and age of sample, then categorized into 2 groups, namely categories ≤ RDA and > RDA.[23]

Physical activity data was obtained from the International Physical Activity Questionnaire (IPAQ). The results of the questionnaire were divided into 2 groups. The first group with low physical activity, if the total physical activity conducted was no more than 600 MET minutes/week and the second group of adolescent with moderate physical activity, namely adolescent who conducted a combination of heavy, moderate and light physical activity with a minimum of 600 MET minutes/week.[24]

Stress level data was obtained by using the DASS 42 (depression anxiety stress scale) questionnaire. The score results obtained from the questionnaire were then divided into 2 groups that are normal group which received a scoring result of 0-14 points and started stress group >14 points.[25] Data regarding


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demographic status including parents' latest education was obtained through the questionnaire given. This research had ethical clearance approval from the Faculty of Medicine, Diponegoro University with letter number 512/EC/KEPK/FK-UNDIP/X/2023.

Statistical analysis in this study used SPSS 26 software. Meanwhile, Chi square and Fisher exact test were used in order to determine the relationship between variables. It is said that there is a significant relationship between variables if it has a p value <0.05. Multivariate analysis in this study used logistic regression.

## RESULTS

The number of respondents used in this study was 80 people in each school, representing the characteristics of adolescents living in urban areas and adolescents living in rural areas. The students sampled came from the same class, in grade 8 of junior high school. The number of male and female students in both urban and rural areas were 40 (50%) each, as well as students who experience obesity and normal nutritional status were 40 (50%) each. The number of respondents living in rural areas aged 12-13 years was 5 people (6.25%) and respondents in the 14-15 year age range were 75 people (93.75%). Respondents who live in urban areas were 72 people (90%) in the 12-13 year age range and 8 people in the 14-15 year age range (10%) are presented in table 1.

**Table 1. Respondent Characteristic in Rural and Urban Area**

| Respondent characteristic | Rural | | Urban | |
|---|---|---|---|---|
| | n | % | n | % |
| Gender | | | | |
| Girl | 40 | 50,0 | 40 | 50,0 |
| Boy | 40 | 50,0 | 40 | 50,0 |
| Nutritional Status | | | | |
| Obese | 40 | 50,0 | 40 | 50,0 |
| Normal | 40 | 50,0 | 40 | 50,0 |
| Age | | | | |
| 12-13 year | 5 | 6,2 | 72 | 90,0 |
| 14-15 year | 75 | 93,8 | 8 | 10,0 |

In table 2, the results of the relationship between several variables included in the risk factors for obesity in rural areas are presented. Based on this table, the factors which are associated with obesity in rural areas are NO2 exposure, SO2 exposure, sleep quality, physical activity, stress levels, protein and carbohydrate intake. The risk factors for obesity in rural areas are exposure to NO2 (OR=2.51, 95%CI: 1.01-6.19) exposure to SO2 (OR=15.54, 95%CI: 3.29-73.41), sleep quality (OR=13.00, 95%CI: 4.15-40.65), physical activity (OR=12.17, 95%CI: 3.63-40.76), stress level (OR=6.64, 95%CI: 1.73-25.46), protein intake (OR=8.75, 95%CI:3.08-24.83) and carbohydrate intake (OR=4.33, 95% CI: 1.69-11.06). The fiber intake of all adolescents does not exceed the RDA since on average they do not like vegetables and they choose certain fruits for consumption and do not consume fruit every day.

**Table 2. Analysis of Factors Associated with Incidence of Obesity in Adolescents in Rural Areas**

| Rural risk factor of obese | Obese | | Normal | | P Value | OR (95% CI) |
|---|---|---|---|---|---|---|
| | n | % | n | % | | |
| Parental education | | | | | | |
| Junior/senior high school | | | | | | |
| College | 23 | 47.9 | 25 | 52.1 | 0.648 | 0.81 |
| NO2 exposure | 17 | 53.1 | 15 | 46.6 | | (0.33-1.98) |
| Tend to high (>median 12,00µg/m3) | 23 | 62.2 | 14 | 37.8 | 0.044a | 2.51 |
| Tend to low (≤median 12,00µg/m3) | 17 | 39.5 | 26 | 60.5 | | (1.01-6.19) |
| SO2 exposure | | | | | | |

*Table 2. Analysis of Factors Associated with Incidence of Obesity in Adolescents in Rural Areas (Lanjutan…)*


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| Rural risk factor of obese | Obese | | P Value | | P Value | OR (95% CI) |
|---|---|---|---|---|---|---|
| | n | % | n | % | | |
| Tend to high (>median 11,08µg/m3) | 38 | 95.0 | 22 | 36.7 | <0.001a | 15.54 (3.29-73.41) |
| Tend to low (≤median 11,08µg/m3) | 2 | 5.0 | 18 | 90.0 | | |
| Sleep quality | | | | | | |
| bad sleep quality | 35 | 71.4 | 14 | 28.6 | <0.001a | 13.00 |
| good sleep quality | 5 | 16.1 | 26 | 83.9 | | (4.15-40.65) |
| Sleep duration | | | | | | |
| Insufficient sleep | 10 | 47.6 | 11 | 52.4 | 0.799a | 0.87 |
| sufficient sleep | 30 | 50.8 | 29 | 49.2 | | (0.32-2.38) |
| Physical activity | | | | | | |
| Low physical activity | 23 | 85.2 | 4 | 14.8 | <0,001a | 12.17 |
| Moderate physical activity | 17 | 32.1 | 36 | 67.9 | | (3.63-40.76) |
| Stress level | | | | | | |
| Start to stress | 37 | 58.7 | 26 | 41.3 | 0.003a | 6.64 |
| Normal | 3 | 17.6 | 14 | 82.4 | | (1.73-25.46) |
| Protein Intake | | | | | | |
| >RDA | 33 | 70.2 | 14 | 29.8 | <0,001a | 8.75 |
| ≤RDA | 7 | 21.2 | 26 | 78.8 | | (3.08-24.83) |
| Fat Intake | | | | | | |
| >RDA | 0 | 0 | 2 | 100 | 0.494b | - |
| ≤RDA | 40 | 51.3 | 38 | 48.7 | | |
| Carbohydrate intake | | | | | | |
| >RDA | 26 | 68.4 | 12 | 31.6 | 0.002a | 4.33 |
| ≤RDA | 14 | 33.3 | 28 | 66.7 | | (1.69-11.06) |
| Fiber intake | | | | | | |
| >RDA | 40 | 50.0 | 40 | 50.0 | - | - |
| ≤RDA | - | - | - | - | | |

[a]Chi Square test [b]Fisher test

The results of bivariate analysis in adolescents living in urban areas are presented in table 3. Factors associated with the incidence of obesity in urban adolescents (P<0.005) are parental education, exposure to NO2 and SO2, sleep quality, physical activity, stress levels, protein intake. and carbohydrates. Moreover, risk factors which cause obesity in urban adolescents are exposure to PM10 (OR=2.40, 95%CI: 0.87-6.55) exposure to O3 (OR=2.40, 95%CI:0.87-6 .55), sleep quality (OR=14.14, 95%CI: 4.77-41.85), physical activity (OR=10.09, 95%CI:2.66-38.20), stress level (OR=10.33, 95%CI:3.68-28.97), protein intake (OR=12.00, 95%CI:4.18-34.45) and carbohydrate intake (OR=14.93 , 95%CI:4.91-45.38). The lack of fiber intake among adolescents in urban areas is the same as among adolescents in rural areas since many of them do not like vegetables and various fruits. In addition, the majority of them consume snacks which are rich in calories, sodium and consume drinks that are high in sugar.

**Table 3. Analysis of Factors Associated with Incidence of Obesity in Adolescents in Urban Areas**

| Rural risk factor of obese | Obese | | Normal | | P Value | OR (95% CI) |
|---|---|---|---|---|---|---|
| | n | % | n | % | | |
| Parental education | | | | | | |
| Junior or Senior high school | 11 | 35.5 | 20 | 64.5 | 0.039a | 0.38 |
| College | 29 | 59.2 | 20 | 40.8 | | (1.50-0.96) |
| PM10 exposure | | | | | | |
| Tend to high (>median 35,00µg/m3) | 15 | 65.2 | 8 | 34.8 | 0.084a | 2.40 (0.87-6.55) |
| Tend to low (≤median 35,00µg/m3) | 25 | 43.9 | 32 | 56.1 | | |
| O3 exposure | | | | | | |
| Tend to high (>median 152,00µg/m3) | 15 | 65.2 | 8 | 34.8 | 0.084a | 2.40 (0.87-6.55) |


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*Table 3. Analysis of Factors Associated with Incidence of Obesity in Adolescents in Urban Areas(Lanjutan…)*

| Rural risk factor of obese | Obese | | Normal | | P Value | OR (95% CI) |
|---|---|---|---|---|---|---|
| | n | % | n | % | | |
| Tend to low (≤median 152,00µg/m3) | 25 | 43.9 | 32 | 56.1 | | |
| NO2 exposure | | | | | | |
| Tend to high (>median 19,00µg/m3) | 6 | 28.6 | 15 | 71.4 | 0.022a | 0.29 (0.10-0.86) |
| Tend to low (≤median 19,00µg/m3) | 34 | 57.6 | 25 | 42.4 | | |
| SO2 exposure | | | | | | |
| Tend to high (>median 29,00µg/m3) | 6 | 28.6 | 15 | 71.4 | 0.022a | 0.29 (1.10-0.86) |
| Tend to low (≤median 29,00µg/m3) | 34 | 57.6 | 25 | 42.4 | | |
| Sleep quality | 33 | 76.7 | 10 | 23.3 | <0.001a | 14.14 |
| Bad sleep quality | 7 | 18.9 | 30 | 81.1 | | (4.77-41.85) |
| Good sleep quality | | | | | | |
| Sleep duration | 16 | 47.1 | 18 | 52.9 | 0.651a | 0.81 |
| Insufficient | 24 | 52.2 | 22 | 47.8 | | (0.33-1.98) |
| Sufficient | | | | | | |
| Physical activity | 18 | 85.7 | 3 | 14.3 | <0.001a | 10.09 |
| Low physical activity | 22 | 37.3 | 37 | 62.7 | | (2.66-38.20) |
| Moderate physical activity | | | | | | |
| Stress level | 31 | 75.6 | 10 | 24.4 | <0.001a | 10.33 |
| Start to stress | 9 | 23.1 | 30 | 76.9 | | (3.68-28.97) |
| Normal | | | | | | |
| Protein intake | 30 | 78.9 | 8 | 21.1 | <0.001a | 12.00 |
| >RDA | 10 | 23.8 | 32 | 76,2 | | (4.18-34.45) |
| ≤RDA | | | | | | |
| Fat intake | 1 | 50.0 | 1 | 50.0 | 1.00b | 1.00 |
| >RDA | 39 | 50.0 | 39 | 50.0 | | (0,60-16,56) |
| ≤RDA | | | | | | |
| Carbohydrate intake | 29 | 82.9 | 6 | 17.1 | <0,001a | 14,93 |
| >RDA | 11 | 24,4 | 34 | 75,6 | | (4.91-45.38) |
| ≤RDA | | | | | | |
| Fiber intake | 40 | 50 | 40 | 50 | - | - |
| >RDA | | | | | | |
| ≤RDA | | | | | | |

aChi Square test bFisher test

**Table 4. Multivariate Analysis Rural Determinant of Obese**

| Variable | Coefficient | P value | OR (CI 95%) |
|---|---|---|---|
| Protein Intake | 2.297 | 0.003 | 9.948 (2.179-45.414) |
| Physical Activity | 3.095 | 0.005 | 22.094 (2.593-188.265) |
| SO2 exposure | 2.987 | 0.005 | 19.817 (2.443-160.779) |
| Sleep quality | 2.186 | 0.007 | 8.901 (1.817-43.592) |
| Konstanta | -5.890 | <0.001 | |

**Table 5 Multivariate Analysis Urban Determinant of Obese**

| Variable | Coefficient | P value | OR (CI95%) |
|---|---|---|---|
| Protein Intake | 3.071 | 0.001 | 21.570 (3.335-139.521) |
| Sleep Quality | 2.806 | 0.002 | 16.550 (2.843-96.354) |
| Stress level | 2.768 | 0.006 | 15.922 (2.245-112.920) |
| Carbohydrate Intake | 1.161 | 0.072 | 5.044 (0.863-29.483) |
| Konstanta | -5.127 | <0.001 | |

In tables 4 and 5 are the results of logistic regression of the incidence of obesity in adolescents in rural and urban areas. The determinants of obesity in adolescents in rural areas are protein intake more than


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RDA (p=0.003 OR=9.948, 95%CI:2.17-45.41), low physical activity (P=0.005 OR=22.094, 95%CI:2.93-188 .26) tend to high SO2 exposure (P=0.005 OR=19.817, 95%CI:2.4160.77) and bad sleep quality (P=0.007 OR=8.901, 95%CI:1.81-43.59) while in adolescents in urban are protein intake more than RDA (p=0.001 OR=21.570, 95%CI:3.33-139.52), poor sleep quality (p=0.002 OR=16.550, 95%CI:2.84-96.35), stressed (p=0.006 OR=15.922, 95%CI:2.24-112.92) and carbohydrate intake more than RDA (p=0.072 OR=5.044, 95%CI:0.86-29.48).

## DISCUSSION

The results of this study which had been conducted on adolescent in rural and urban areas show that parental education is related to the incidence of obesity in urban areas but not in rural areas. Parents who do not have higher education are a protective factor against the incidence of obesity adolescent in urban and rural area. Low parental education had been link to a decrease risk of obesity in adolescent.[26] Previous study mention that high level of parental education can increase incidence of obesity.[27] Parents who have higher education have potential to have better jobs in line with their income so that the family's purchasing power will increase in fulfilling family food. Parent with high mobility often choose quick and easy meals like instant food and Ultra processed food (UPF), even though this food might not be healthy. Frozen food are convenient, has minimal nutrition. Higher education obtained by parents will not influence the process of providing food which is suitable for balanced nutrition, if the parents do not have good knowledge about nutrition.[26,27]

The results of analysis show that exposure to $NO_2$ and $SO_2$ is related to the incidence of obesity in both urban and rural adolescents. Exposure to PM10 and $O_3$, which tends to be higher in urban adolescents, will increase the risk of obesity, but not $SO_2$ and $NO_2$ exposure. In contrast to the results of study in rural areas, exposure to $SO_2$ and $NO_2$ pollution is considered as factor which increases the risk of obesity. Furthermore, research which had been conducted previously in the population of children and adolescents in China, explains that exposure to air pollution PM10, PM2.5, PM1 and $NO_2$ has a strong relationship with increasing BMI scores, waist circumference and the ratio of waist circumference to height in adolescents.[14] Long-term exposure to particles <10 PM10, Nitrogen dioxide ($NO_2$), sulfur dioxide ($SO_2$) and ozone ($O_3$) is associated with increased incidence of obesity in children and adolescents which is in line with research conducted cross-sectionally and longitudinally in Northern China and Spain.[28,29] The mechanism of pollution exposure and the incidence of obesity is not yet fully understood in humans but animal experiments have been conducted. Research which had been conducted on rats, found that the average body weight of rats, levels of MDA (malondialdehyde) in the lungs, liver and brain tissue are higher in rat exposed to air without HEPA filters in indoor areas located in the north of Beijing.[30] High levels of MDA in the rat's body indicate high levels of oxidative stress. Exposure to pollution which causes oxidative stress is related to obesity. In addition to oxidative stress, exposure to pollution is closely related to inflammation in adipose tissue and the synthesis and release of cytokines, this condition play role in developing obesity.[31,32]

Based on the results of the analysis conducted in this study, poor sleep quality will increase the risk of adolescents becoming obese. In accordance with previous research conducted on a population of children and adolescents aged 8-16 years in Shanghai, poor sleep quality increases the risk of overweight and obesity.[10] It in line with research which had been conducted in India, poor sleep quality is a risk factor for obesity.[33] Poor sleep quality causes decreased productivity during the day so that there is a possibility which adolescents will tend to be less active and have decreased concentration when studying. Several mechanisms explain factors link sleep quality to obesity. These include increased food intake due to longer waking hours, and hormonal changes during sleep that can affect increasing hunger hormone (ghrelin) and decreasing fullness hormone (leptin).[10,34]

Sleep duration in this study was not related to the incidence of obesity in adolescents, both in urban and rural areas. Based on data average sleep duration among adolescent in urban and rural are 7 hours each night which means lower than recommendation. The results of this research are not in line with many previous studies which state that sleep duration is associated with increased BMI and risk for obesity.[10,35] However, the results of this study are in line with research which had been conducted in Semarang on a sample aged 15-18 years that there is no difference between the sleep duration of obese adolescents and non-obese adolescents.[36] Inadequate sleep duration in teenagers is due to the habit of playing with smartphones, whether scrolling social media or playing games, as well as the demands of school work which makes adolescents more awake at night.


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Bivariate analysis between physical activity variables and the incidence of obesity in rural and urban adolescents is significantly related since low physical activity increases the risk of obesity. In accordance with research which had been conducted in Gorontalo and Samarinda, physical activity is related to the incidence of obesity in adolescents.[37,38] Adolescents who live in urban and rural areas have almost the same activity patterns every day. With a busy schedule of learning and teaching activities from 07.00 WIB (7 AM) to 14.00 WIB (2 PM) or 16.00 WIB (4 PM), then spend the rest of the time playing on cellphones (social media, online games) and studying again at evening. On average, adolescents only do heavy physical activity during sports lessons at school once a week. Lack of moderate and light activity which occurs continuously will facilitate fat deposits without realizing it.[39]

The results of the study show that the level of stress experienced by adolescents is related to and increases the risk of obesity in both adolescents who live in urban areas and adolescents who live in rural areas. Furthermore, stress which occurs chronically or for a long time causes disturbances so that it activates the Hypothalamus Pituitary Aderenal (HPA) axis causing the secretion of cortisol and glucocorticoid hormones which encourage the consumption of high palatable foods.[40]

The ghrelin hormone, which is a hunger hormone, is one of the biomarkers in order to see the level of stress experienced by a person since the role of this hormone causes a person to experience stress eating so that it increases the desire to eat and self-reward to relieve stress.[41] In research which had been conducted cross-sectionally in East Bintan and Sukoharjo, according to the results of the research we conducted, there is a relationship between the level of stress experienced by adolescents and the incidence of obesity.[42,43]

Food intake plays an important role in the incidence of obesity because of the imbalance between energy intake and energy expenditure.[3] Based on research results, protein and carbohydrate intake is related to the incidence of obesity in adolescents in urban and rural areas. The average teenager consumes complex carbohydrates in the form of rice, potatoes or cassava as much as 550-800 grams and various sweet drinks; such as, powdered drinks, tea and coffee drinks and syrup at least 100-500 ml per day. Moreover, the protein consumed by obese adolescents on average exceeds the daily RDA since these teenagers consume 2 types of protein sources in one meal, usually a combination of animal and vegetable protein. Only a few adolescents consume more fat than the RDA since they are more likely to eat foods which are high in carbohydrates. Adolescents who live in urban and rural areas consume very little fiber, in fact none of them consume daily fiber according to the RDA since most of them do not consume vegetables and only like certain fruits. Excessive consumption of carbohydrates and protein will be stored in the form of fat if not excreted, making it possible to be overweight. When protein and carbohydrates are excessive they will be stored into triglycerides, if protein and carbohydrates they will be transformed into Acetyl Coa.[44] The results of this study are similar to research which had been conducted in Malang on 111 adolescents, consumption of foods with high protein and carbohydrates is associated with overweight and obesity.[44] In line with research which had been in China, high consumption of carbohydrates from snacks is associated with the incidence of obesity.[45]

Based on the multivariate analysis conducted, the determinants of obesity in rural areas are high protein intake, low physical activity, high exposure of $SO_2$ and bad sleep quality and in urban areas are protein intake more than RDA, bad sleep quality, stressed and high carbohydrate intake. In this research level of $SO_2$ exposure in urban area are higher than rural area, show with median value that mention before. High pollution in urban areas is not a risk factor for obesity. It is inversely proportional to the incidence in rural areas. $SO_2$ exposure is one of the risks of obesity which is in line with research which had been conducted in China. In this study, the effect of air exposure in rural areas actually has a greater effect on incidence of obesity.[46] This occurs in rural areas due to a lack of attention to personal health protection; such as using masks. Protein intake is the biggest determinant of the incidence of obesity in adolescents in both rural and urban areas. In addition, high protein intake will cause central obesity and it is associated with adolescent health.[47] Animal protein contains high levels of fat, cholesterol, and sugar. So that excessive consumption and lasting for a long time will increase the risk of obesity.[48] Study on adolescent in Michigan and California found that adolescent who ate more total protein, especially animal protein, certain amino acids (BCAAs and SCAAs), tended to have more body fat. This includes both overall body fat (measured by BMI-for-age) and belly fat (measured by waist-to-height ratio).[47] In line with research in children and preadolescent in Italy mention that energy intake from protein was positively associated with BMI and waist to high ratio.[49]

In this study there are several weaknesses. First, the subjects did not measure oxidative stress levels in order to see the extent to which pollution exposure could influence the incidence of adolescent obesity.


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Second, bias in interviews about intake may occur due to the limited memory of adolescents about the intake consumed.

## CONCLUSIONS

Based on the study, it can be concluded that protein intake is the biggest determining factor in the incidence of obesity found in both adolescents living in urban and rural areas. In addition to protein, sleep quality is a determining factor in the sample. Exposure to SO2 air pollution has a greater effect on adolescents who live in rural areas becoming obese. Sustainable air pollution control measures should not only be focused on urban areas, but rural areas should also be given more attention. Increase amount of number AQMS (air quality monitoring system) in several crucial location and do calibration regularly. Strategies for improving the nutritional status of adolescents and children should be specific and based on location, considering the differences between the factors which cause obesity in urban and rural adolescents. In addition, knowledge regards to balanced nutrition needs to be established and integrated with the school curriculum with the aim of promoting healthy food consumption, providing an invitation to always consume vegetables and fruit, sufficient and good quality sleep and always be physically active.

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