Abdominal Diameter Profiles Related to Visceral Obesity Based on Lipid Accumulation Product in Obese Adolescent Females

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Abstract

Background: The prevalence of abdominal obesity followed by excess visceral fat in females is greater than males. Furthermore, one of the anthropometric measurements that has not been widely used and further analyzed is related to excess accumulation of visceral fat mass, namely abdominal diameter (SAD, SAD/Height, ADI).

Aims: This study aimed to analyze the relationship between abdominal diameter and visceral obesity (based on Lipid Accumulation Product values) in obese adolescent females.

Settings and Design: This study was included in the scope of community nutrition which is observational analytic with a cross-sectional design.

Methods and Material: A cross-sectional design was used, and 112 subjects were selected by random sampling method, with an age range of 18-21 years.

Statistical analysis used: The statistical analysis used Kolmogorov-Smirnov for normality data test and Spearman rank test for bivariate data analysis.

Results: 42% of the subjects had SAD values that were classified as risky, 24.1% had risky SAD/Height values, and 97.3% had ADI values that were classified as not at risk. In addition, females with visceral obesity based on LAP values were 26.8%.

Conclusions: There was a relationship between each abdominal diameter profile with LAP with a positive correlation direction.

Keywords: Sagittal Abdominal Diameter (SAD), Sagittal Abdominal Diameter/Height (SAD/Height), Abdominal Diameter Index (ADI), Lipid Accumulation Product (LAP).

Key Messages:

Abdominal diameter profile is an anthropometric indicator which can be manually performed using an abdominal caliper. It focuses on the measurement of visceral fat mass in the abdominal cavity, which has an important role in the development of metabolic abnormalities, insulin resistance, and pathogenesis of other obesity complications.

http://doi.org/10.36295/ASRO.2021.24136
Introduction

Obesity has become a global health problem (global epidemic) because of its increasing prevalence, not only in adults but also in adolescents both in developed and developing countries, including Indonesia.\(^1\) Furthermore, adolescents obesity is influenced by gender, and young females are found to be more prone than males. This is because of its association with differences in body fat percentage. Also, the percentage of body fat in females is greater than in males, and it generally increases with age, including in adolescents at puberty.\(^2,3\)

The prevalence of abdominal obesity at age more than 15 years old in Indonesia based on Riset Kesehatan Dasar (Riskesdas) in 2013 was 26.6%, and reached 31% in 2018. Also, the prevalence at age more than 15 years old in Central Java Province based on Riskesdas in 2013 was 24.7% and 28.8% in 2018.\(^4-7\) Furthermore, results of research conducted on 516 adolescents in Semarang showed 8.9% or 46 people had abdominal obesity.\(^8\) Further analysis using Riskesdas 2013 data showed that the prevalence in females was greater than males, which was 56.3% compared to 43.7%.\(^9\)

Abdominal obesity that occurs in a person is inseparable from excess visceral fat accumulation, which is concentrated in the intra abdominal region (abdominal cavity).\(^10\) Also, excessive mass of visceral adipose tissue can cause visceral obesity. Meanwhile, fat accumulation in the visceral is in a form of non-functioning subcutaneous fat tissue in the face of a positive energy balance.\(^11\) When compared to peripheral obesity, visceral obesity is more sensitive as a predictor of metabolic syndrome risk, such as increased triglyceride level, hypertension, decreased HDL, and increased blood sugar levels. This is because this type of obesity has a strong association with the incidence of subclinical inflammation.\(^12,13\) Therefore, a simple indicator that have been developed to show a continuous risk, as well as predict metabolic syndrome is by calculating the value of Lipid Accumulation Product (LAP).\(^14,15\)

The LAP formulation is used as an indicator of clinical anthropometry, which is good enough to estimate visceral obesity. Further research analysis showed that the use of serum triglyceride levels and anthropometric index in the form of a waist circumference formulated into LAP values could accurately estimate visceral accumulation compared to only anthropometric index.\(^15,16\) Based on previous research, LAP is a better indicator of fat accumulation compared to the Visceral Adipose Index (VAI). This is because it is seen from visceral adipose tissue (VAT) based on the results of
comparison using computed tomography (CT) and a sensitivity Positive Predictive Value (PPV) of 83.3 in females aged 20-59. Meanwhile, this PPV is greater when compared with the Visceral Adiposity Index (VAI), which is 66.7. In addition, the results of the same study showed that the Areas Under Curve (AUC) value is 0.78, which means it is better than the VAI which is only 0.65.\textsuperscript{15}

Excessive visceral fat in an individual with visceral obesity can also be measured using abdominal diameter. The superiority of this measurement is that it is the only anthropometric indicator which can be manually carried out with an abdominal caliper. Furthermore, it focuses on the measurement of visceral fat mass in the abdominal cavity which plays an important role in metabolic abnormalities development, insulin resistance, and pathogenesis of other obesity complications.\textsuperscript{12,17,18} Also, abdominal diameter is an anthropometric measurement method that is fast, inexpensive, non-invasive (minimally risk), reliable, and valid regardless of individual body size. This is unlike waist circumference measurements which are more difficult to accurately measure, and require repeated measurements in obese people with large abdomen.\textsuperscript{19}

Abdominal diameter is divided into three measurements based on the anthropometric index used, including Sagittal Abdominal Diameter (SAD), SAD/Height, and Abdominal Diameter Index (ADI).\textsuperscript{20} The Sagittal diameter is an anthropometric measurement of a person's abdomen height based on visceral fat deposition in the abdominal cavity (intra abdominal). In fact, several studies have reported a close relationship between SAD and visceral fat.\textsuperscript{18,21,22} SAD/Height is part of the abdominal diameter. This measurement adds height data in centimetre (cm) as a size divisor of the sagittal abdominal diameter. The SAD/Height has a significant correlation with cardiovascular risk and is as good as SAD.\textsuperscript{23,24} Meanwhile, ADI is obtained from the ratio of SAD to thigh circumference. In several studies, ADI has been considered as an effective and better indicator of the hip waist circumference ratio to estimate visceral adipose tissue.\textsuperscript{25,26} Nevertheless, research on measuring abdominal diameter (SAD, SAD/Height and ADI) as a predictor of visceral obesity has not been deeply conducted, especially in Indonesia. Therefore, based on these background researchers are interested in analyzing the relationship between abdominal diameter and visceral obesity based on LAP values, and to identify the incidence of visceral obesity in obese adolescent females.

**Subjects and Methods**

**Design, location and time**

This Study was an observational analytic with a cross-sectional design. It was conducted in June-August 2019 with students of Universitas Diponegoro, Semarang as the subject.
Subjects and Samplings

The selection of subjects began with the screening process for female students across 10 faculties of Universitas Diponegoro, and 1260 subjects were obtained. Furthermore, those who meet the inclusion criteria were selected using a random sampling method of 120 people. However, 8 subjects dropped out because the data did not match, including height, weight, waist and thigh circumference, as well as triglyceride levels; therefore the analyzed data were 112 subjects. Also, the inclusion criteria were active students that are willing to be a research sample by filling out a willingness form as subject, female, aged 17-21 years, having a waist circumference >80 cm, not currently carrying out a certain diet, not taking a drugs that affect triglyceride levels, willing to fast at least 8 hours before blood is drawn, and able to communicate effectively. Meanwhile, the exclusion criterion was that the subject resigned during the study. In addition, the implementation of this study was approved by the Medical or Health Research Bioethics Commission, Faculty of Medicine, Sultan Agung Islamic University, Semarang Number 011/I/2020/Bioethics Commission.

Figure 1. Subject Selection Flow

Data Collected

The independent variables in this study were abdominal diameter consisting of Sagittal Abdominal Diameter (SAD), Sagittal Abdominal Diameter/Height (SAD/Height), and Abdominal...
Diameter Index (ADI). Furthermore, the SAD was manually measured using an abdominal calliper. In this study, the calliper used was AbawerkSchaffenburg brand with a precision of 1 millimetre. In addition, height was measured using a stadiometer with an accuracy of 1 millimetre, thigh and waist circumference were measured using a measuring tape (Medline) with an accuracy of 1 millimetre.

SAD measurements were made with the subject lying supine on a flat pedestal with both knees forming a 90° angle, both feet flat on the table, hands crossed over the chest, then measured on the hip bone line (iliac crest). Furthermore, the subjects were asked to inhale and exhale slowly, then hold their breath for a moment. The upper calliper arm was then lowered until it was just above the navel (parallel to the iliac crest).12,18

SAD is categorized as not at risk when it is ≤19.3 cm and at risk when it is >19.3 cm.18 Meanwhile, SAD/Height is a derivative of SAD measurement found from a comparison or ratio between SAD values and height in centimetre. SAD/Height is categorized as not at risk when it is ≤0.13 and at risk when it is >0.13.27 Furthermore, ADI is a derivative of SAD measurement by measuring the SAD ratio with thigh circumference in centimetre. The thigh circumference was measured on the right side of the body at a midpoint between the folds of inguinal crease and a proximal limit of the kneecap (patella). In addition, ADI is categorized as not at risk when it is ≤0.38 and at-risk when it is >0.38.27

The dependent variable in this study was the Lipid Accumulation Product (LAP). Based on previous studies, LAP has been proven to be a simple and effective indicator associated with excess visceral fat mass. In fact, subsequent studies have shown that when a person's LAP value exceeds the cut-off, it can be estimated that they have visceral obesity.14 Therefore, LAP is categorized as normal when it is ≤40.60 and high when it is ≥40.61.15
LAP is seen based on increased levels of triglycerides and waist circumference. Therefore, the greater the triglycerides value and a person's waist circumference, the higher the LAP value. Triglyceride levels were tested using the GPO-PAP method in clinical laboratory. In addition, determination of the LAP value was distinguished according to gender, and in females, LAP value was obtained through calculations:

\[
\text{LAP} = [\text{waist circumference (cm)} - 58] \times \text{triglyceride (mmol/L)}
\]

Data Analysis

Univariate data analysis was used to describe the characteristics of each variable, determine the distribution and normality test of numerical data. Furthermore, data normality test in this study used the Kolmogorov Smirnov test. Also, bivariate data analysis used the Spearman rank test for abnormal data with a significance level (\(\alpha\)) of 0.05 and a confidence level of 95%. The purpose of the bivariate analysis was to determine the relationship of each abdominal diameter variable (SAD, SAD/Height, ADI) to the LAP.

Results

Subject Characteristics

The subject characteristics table showed that the age range was between 18 to 21 years old with a median age of 19 years old. Furthermore, the median triglyceride level of the subject was 90.50 mg/dL, and the highest waist circumference value was 114 with a median value of 86. Also, the range of Sagittal Abdominal Diameter (SAD) values in the subjects was 14.9-26.1 cm. The range of SAD/Height values was 0.10-0.17, and the range of ADI values was 0.25-0.40. In addition, the highest LAP value was 87.47 mmol/L, while the lowest was 11.41 mmol/L.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>18.00</td>
<td>21.00</td>
<td>19.00</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>50.80</td>
<td>107.40</td>
<td>67.00</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>141.2</td>
<td>171.40</td>
<td>157.50</td>
</tr>
<tr>
<td>Waist Circumference (cm)</td>
<td>80.50</td>
<td>114.00</td>
<td>86.00</td>
</tr>
<tr>
<td>Thigh Circumference (cm)</td>
<td>46.50</td>
<td>78.40</td>
<td>57.80</td>
</tr>
<tr>
<td>Triglycerides (mg/dL)</td>
<td>43.00</td>
<td>254.00</td>
<td>90.50</td>
</tr>
<tr>
<td>Triglycerides (mmol/L)</td>
<td>0.49</td>
<td>2.87</td>
<td>1.02</td>
</tr>
<tr>
<td>Sagittal Abdominal Diameter (cm)</td>
<td>14.90</td>
<td>26.10</td>
<td>18.80</td>
</tr>
<tr>
<td>Sagittal Abdominal Diameter/Height (ratio)</td>
<td>0.10</td>
<td>0.17</td>
<td>0.12</td>
</tr>
<tr>
<td>Abdominal Diameter Index/ ADI (ratio)</td>
<td>0.25</td>
<td>0.40</td>
<td>0.32</td>
</tr>
<tr>
<td>Lipid Accumulation Product (LAP value)</td>
<td>11.41</td>
<td>87.47</td>
<td>31.04</td>
</tr>
</tbody>
</table>
In the variable frequency distribution table, the results showed that almost half of the subjects (42%) have a SAD value that is classified risky. Meanwhile 24.1% are classified as risky based on SAD/Height values. Almost all subjects (97.3%) had ADI values classified as normal or not at risk. In addition, those with visceral obesity based on Lipid Accumulation Product (LAP) values were 26.8%.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>n</th>
<th>%</th>
</tr>
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<tbody>
<tr>
<td>Sagittal Abdominal Diameter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No risk</td>
<td>65</td>
<td>58</td>
</tr>
<tr>
<td>At risk</td>
<td>47</td>
<td>42</td>
</tr>
<tr>
<td>Sagittal Abdominal Diameter/Height</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No risk</td>
<td>85</td>
<td>75.9</td>
</tr>
<tr>
<td>At risk</td>
<td>27</td>
<td>24.1</td>
</tr>
<tr>
<td>Abdominal Diameter Index</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No risk</td>
<td>109</td>
<td>97.3</td>
</tr>
<tr>
<td>At risk</td>
<td>3</td>
<td>2.7</td>
</tr>
<tr>
<td>Lipid Accumulation Product</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal (≤40.60)</td>
<td>82</td>
<td>73.2</td>
</tr>
<tr>
<td>Height (≥40.61)</td>
<td>30</td>
<td>26.8</td>
</tr>
</tbody>
</table>

Relationship of abdominal diameter with Lipid Accumulation Product

Bivariate analysis by the Rank Spearman test showed that Sagittal Abdominal Diameter, SAD/Height and Abdominal Diameter Index have a significant correlation with LAP (p <0.05) with positive correlation direction. Furthermore, the best correlation strength among abdominal diameter variables to LAP was SAD with r-value of 0.461. The complete results are shown in Table 3.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Lipid Accumulation Product</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>r</td>
</tr>
<tr>
<td>Sagittal Abdominal Diameter</td>
<td>0.461</td>
</tr>
<tr>
<td>SAD/Height</td>
<td>0.406</td>
</tr>
<tr>
<td>Abdominal Diameter Index</td>
<td>0.205</td>
</tr>
</tbody>
</table>

Discussion

The results showed that the median Sagittal Abdominal Diameter (SAD) of the subjects were 18.80 cm with a minimum value of 14.90 cm and a maximum of 26.10 cm. SAD is an anthropometric instrumentation used to represent the accumulation of visceral adipose tissue in the abdominal cavity. Furthermore, it can be manually carried out using abdominal caliper. Manual SAD measurement also has a close relationship with the amount of visceral fat accumulation. This is because during the measurement, the position of the subject is supine (lying), where the accumulation of subcutaneous...
fat tissue moves to the side of the waist. Therefore, measurements at these positions reflect intra-abdominal fat width in the anteroposterior plane, as well as measurements made with Magnetic Resonance Imaging (MRI) or Computed Tomography (CT).\cite{18,20} As many as 42% of subjects in this study had SAD values classified as risky. Meanwhile, the results of previous studies showed that SAD is a strong anthropometric predictor of visceral fat. When compared to other measurements, such as waist or waist-hip circumference ratio, SAD has a better correlation with parameters hemodynamics and biochemistry associated with cardiovascular disease and metabolic syndrome in obese subjects.\cite{12}

Based on the results of this study, almost half of the subjects were at risk based on SAD value. It could be interpreted that the SAD measurement only focused on measuring visceral fat mass without being compared to others, such as height or thigh circumference. Therefore, SAD is the best abdominal diameter profile in reflecting one's visceral fat deposit. This is also supported by the results of previous studies that the correlation coefficient value of SAD to visceral adipose tissue (VAT) was better than SAD/Height or ADI which was equal to 0.75.\cite{27}

SAD/Height has a median value of 0.12 with a minimum value of 0.10 and a maximum of 0.17. Meanwhile, as many as 24.1% of subjects had a SAD/Height value that was classified as risky. Furthermore, SAD/Height has a strong correlation with cardiovascular risk and it is as good as SAD.\cite{23,24} Based on a study conducted in Salvador City, Brazil on 100 adults and 94 elderly, it was found that the correlation between visceral adipose tissue and SAD/Height was more significant in adult females compared to elderly, with correlation results (r) of 0.73 and 0.64 respectively. The results of the study showed that SAD/Height measurements were more significantly performed on female subjects aged 20 compared to elderly.\cite{27} Based on SAD/Height calculation values, it can be seen that the taller the person, the smaller the SAD/Height value, and vice versa. Also, when the posture is short but the SAD value is high, then the SAD/Height value will be high as well. This is reflected in the results of this study, in which only 24.1% have a risky SAD/Height value. Even though the subjects have a high SAD value, but as long as the posture is tall, the ratio of the SAD/Height value will becomes smaller or normal when compared to only SAD values.

Abdominal Diameter Index (ADI) has a median value of 0.32 with a minimum of 0.25 and maximum of 0.40. Almost all subjects (97.3%) in this study had ADI values classified as not risky, and only 2.7% were classified as risky. Furthermore, ADI has been considered in several studies as an effective indicator of the hip waist circumference ratio to estimate visceral adipose tissue. Also, it is a good predictor of cardiovascular ischemic cumulative risk and coronary heart disease.\cite{25,26} The research conducted in Salvador City Brazil showed that the correlation between visceral adipose tissue and ADI was more significant in adult females compared to elderly, with correlation results (r) of
0.67 and 0.48, respectively. From these results, it can be concluded that the ADI measurements have good predictive ability related to the correlation with Visceral Adipose Tissue (VAT) in adult female subjects.\(^{27}\)

Based on the results of this study, there were only 2.7% with ADI values at risk. This is related to differences in the type of obesity between male and female. Females tend to have the characteristics of fat deposits allocated at the edges and bottom of the body, which is around the hips and thighs, hence the body is shaped like a pear (pear shape).\(^{30}\) Meanwhile, the magnitude of each SAD value and thigh circumference also affect the ADI value. Therefore, when SAD value is high and the circumference of the thigh is small, then the ratio of the ADI value will be high. Meanwhile, when SAD is low and the circumference of the thigh is high, then the ratio of ADI value will be low. The small ADI value ratio is related to the type of pear obesity in female. This is due to the big thigh circumference as a divisor of SAD. In this study, almost all subject populations have ADI values that are not at risk, although 42% of the subjects were found to have large SAD values, which is due to their big thigh circumference. This study also found that subjects classified as at risk based on the ratio of ADI values were less compared to only SAD values. These results are supported by previous studies which showed that ADI is better used as a predictor of excess visceral fat in males than in females, due to its association with this form of obesity.\(^{27}\)

The accumulation of visceral fat based on the formulation of Lipid Accumulation Product (LAP) resulted in a median value of 31.04 with a minimum of 11.41 and maximum of 87.47. Also, as many as 26.8% of the subjects had a high LAP value. Based on previous research, when an individual has high LAP value, it can be estimated that the person has visceral obesity.\(^{15}\) LAP was developed as a predictor of metabolic syndrome due to excess visceral fat accumulation in individual with visceral obesity. Meanwhile, the National Health and Nutrition Examination Survey III showed that LAP has better performance than BMI in identifying the risk magnitude of cardiovascular disease, such as high total and LDL, low HDL and uric acid levels.\(^{14}\) Abdominal fat consists of subcutaneous and intra-abdominal fat (visceral), and the metabolic process is mediated by visceral fat deposits. Furthermore, visceral fat in the body is closely related to metabolic syndrome and other cardiovascular diseases. This is because it is more active and releases pro-inflammatory adipokines more than peripheral fat. Research found that body fat distribution is more influential than the amount of fat itself. Therefore, excess visceral adipose tissue in the abdominal region or known as visceral obesity is more at risk of cardiovascular disorders than other types of obesity. This is due to higher visceral fat deposition.\(^{31}\)

Volume accumulation and visceral fat deposits in the abdominal cavity and its association with the incidence of visceral obesity can be determined through anthropometric instruments in the form of
abdominal diameter (SAD, SAD/Height, ADI) and Lipid Accumulation Product (LAP). Based on previous research, the abdominal diameter has a strong anthropometric relationship with visceral adipose tissue area, which can be a predictor of visceral obesity incidence in a person. One of the parameters that can be used in estimating the accumulation of excess visceral adipose tissue is by measuring the LAP value. The higher the visceral fat accumulation, the greater the value of abdominal diameter (SAD, SAD/Height, and ADI) in a person, which will ultimately affect LAP as a parameter for the incidence of visceral obesity. This was proven in this study that abdominal diameter and LAP variables have a positive correlation.

Bivariate analysis in this study showed that each of the abdominal diameter measurement variables, namely SAD, SAD/Height and ADI were significantly related (p <0.05) to Lipid Accumulation Products, and had a positive relationship direction. The correlation coefficient (r) between SAD to LAP was 0.461, SAD/Height to LAP was 0.406, and ADI to LAP was 0.205. These results are quite different from the r values in previous studies which showed that each category of correlation are better (0.75; 0.73; 0.67) compared to this study. It is because this study focused on the subject, which are young females with an age range of 18-21. Meanwhile, in the previous study the subjects were female with an age range >20-59, and used the computed tomography (CT) as gold standard measurements. Also, age affects the amount of visceral fat accumulation in females. Older females especially after menopause, had greater visceral fat accumulation in the abdominal cavity. In addition, this study used the waist circumference to determine obesity during the screening. This is different from previous studies which used Body Mass Index (BMI) up to 39.9 kg/m2 to determine obesity. Also, the inclusion criteria in previous studies were more heterogeneous in terms of age, number, and genders, such as grouping male and female adult subjects (aged 20-59 years), male subjects and elderly females (aged 60 years and over). The difference between this study and previous research makes the results also quite different when compared.

LAP values depend on waist circumference and triglyceride levels. The greater the waist circumference and triglyceride levels, the higher the LAP value. Waist circumference is a simple measurement of truncal fat (accumulation of truncal/upper body fat or abdominal fat) which can reflect abdominal subcutaneous adipose tissue, especially reflecting visceral adipose. Furthermore, it is a strong predictor of cardiometabolic disease risk, because the greater the accumulation of visceral fat tissue, the greater the person's waist circumference. Also, triglycerides have been recognized as predictors of metabolic syndrome, and have a significant correlation with visceral adipose tissue because triglycerides are the main lipid storage. Furthermore, obesity is associated with abnormal serum lipoprotein levels. Each lipoprotein consists of cholesterol (free or esters), triglycerides,
phospholipids, and apoprotein. Therefore, a person who has visceral obesity (increased visceral adipose tissue mass) usually has higher triglyceride levels in the blood than non-obese people.

The correlation between triglycerides and excess visceral adipose accumulation could be caused by a combination of increased triglyceride production and impaired circulation of triglyceride breakdown in visceral obesity. Also, hyperlipolysis conditions in visceral obesity cause an increase in the entry of fatty acids into the liver and result in the overproduction of triglycerides. Meanwhile, excessive fat accumulation that occurs in obese people increases the amounts of free fatty acids (FFA) which are hydrolyzed by lipoprotein lipase (LPL). This triggers the production of oxidants which have a negative effect on the endoplasmic reticulum and mitochondria. Also, the free Fatty Acid (FFA) released due to excessive accumulation of fat inhibits the occurrence of lipogenesis, thereby inhibiting serum triacylglycerol and resulting in an increase of blood triglyceride levels (hypertriglyceridemia). This means that the increase in waist circumference and triglyceride values will increase the value of LAP as a parameter of visceral obesity.

Conclusion

As many as 42% of subjects had Sagittal Abdominal Diameter (SAD) values that were classified as at risk, 24.1% were at risk based on SAD/Height values, and almost all (97.3%) the subjects had ADI values classified as not at risk. Furthermore, females with visceral obesity based on Lipid Accumulation Product (LAP) values are 26.8%. This research found that there was a positive correlation between abdominal diameter (SAD, SAD/Height, ADI) and Lipid Accumulation Product (LAP) in obese adolescent female (p < 0.05).

Suggestion

Research on abdominal diameter (SAD, SAD/Height, ADI) could be linked to other metabolic profiles such as HDL, LDL, insulin resistance, and blood pressure. Therefore, research on abdominal diameter needs to be simultaneously conducted on obese males and females to compare the differences in visceral fat mass distribution and its association with the risk of developing metabolic syndrome.

Acknowledgement

The author would like to thank the research subjects and the Department of Nutrition Science at the Faculty of Medicine, Universitas Diponegoro. This study was funded by the PDUPT Research Grant in 2019, The Ministry of Research, Technology and Higher Education, Indonesia.
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