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Masters Program in Public Health, Universitas Sebelas Maret

Meta-Analysis

Effects of Overweight and Obesity on Hypertension in Adolescents: A Meta-Analysis

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ABSTRACT

Background: Hypertension is currently starting to show a trend in prevalence that continues to increase at a younger age and is a major cause of premature death in the world. In adolescents, hypertension is more common who are overweight or obese. This study aims to examine the effect of overweight and obesity on the incidence of hypertension in adolescents using a meta-analysis.
Subjects and Method: Meta-analysis was carried out using the PRISMA flow chart and the PICO model. Population: adolescents aged 10 to 19 years. Intervention: overweight and obesity. Comparison: normoweight. Outcome: hypertension). The databases used are PubMed, Science Direct, Springer Link, and Google Scholar with the keywords (hypertension OR "High Blood Pressure") AND "BMI Status" AND (adolescent OR teenager) AND "cross sectional". There were 9 cross-sectional studies published in 2012-2022 with odds ratio (OR) effect size that met the inclusion criteria. Analysis was performed with RevMan 5.3.
Results: A meta-analysis was conducted on 9 articles with a cross-sectional study design originating from China, South Korea, India, Turkey, Tunisia, Lithuania and Poland involving 63,239 adolescents aged 10-19 years. The results of the meta-analysis showed that overweight adolescents were 2.44 times more likely to experience hypertension compared to normal weight adolescents (aOR= 2.44; 95%CI= 1.87 to 3.19; p<0.001), and obese adolescents were more likely to experience hypertension 4.53 times compared with normal weight adolescents (aOR= 4.53; 95% CI= 3.10 to 6.61; p<0.001).
Conclusion: Being overweight and obese can increase the risk of developing hypertension in adolescents.

Keywords: overweight, obesity, hypertension, adolescents, meta-analysis

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BACKGROUND

Hypertension is defined as a condition when blood pressure persistently increases abnormally (Oparil et al., 2019; Singh et al., 2017). By 2020, hypertension is the leading cause of more than 670,000 deaths in the United States (CDC, 2022). One of the global targets for non-communicable diseases is to reduce the prevalence of hypertension by 33% between 2010 and 2030 (WHO, 2021a).

Initially, hypertension was rare in children and adolescents, but now hypertension has shown a trend in prevalence at a younger age (Yang et al., 2021). The CDC

study shows that around 1 in 25 adolescents or as many as 1.3 million adolescents aged 12 to 19 years have hypertension (CDC, 2020). The hypertension that most often occurs in adolescents is essential hypertension, namely hypertension that occurs without symptoms (asymptomatic) and many of them are detected only during routine examinations (Shaumi and Achmad, 2019).

In 2017, the American Academy of Pediatrics (AAP) published new clinical practice guidelines for the diagnosis, evaluation, and treatment of high blood pressure in children and adolescents adjusted for age, height, and sex (CDC, 2020; Samuels and Samuel, 2018). The classification of blood pressure in children aged 1-12 years according to the AAP in 2017 is divided into normal blood pressure, which is less than the 90th percentile, elevated blood pressure, which is between the 90th and 95th percentile, and hypertension is defined as 95th percentile or more (Samuels and Samuel, 2018).

Hypertension experienced by adolescents is related to multifactorial which can't be ascertained as a single cause. In adolescents, high blood pressure is more common in adolescents who are overweight or obese, and indicates a strong relationship between obesity and hypertension in adolescents (Flynn, 2019; Shaumi and Achmad, 2019).

Overweight and obesity are defined as abnormal or excessive fat accumulation that may impair health (WHO, 2021b). For children and adolescents aged 5-19 years, the calculation of BMI (Body Mass Index) needs to take into account age, so that the BMI values obtained are compared with the WHO Growth Reference (WHO, 2021b). Overweight conditions are defined if the BMI value based on age is greater than 1 standard deviation above the WHO Growth Reference median (BMI is equivalent to 25 to <30 kg/m2), while obesity is a condition if the BMI value is greater than 2 standard deviations above the Growth Reference median WHO (BMI equivalent to ≥30 kg/m2) (WHO, 2021b).

In this study, the authors are interested in conducting a meta-analysis of the effects of overweight and obesity on the incidence of hypertension in adolescents. This study aims to examine the effect of overweight and obesity on the incidence of hypertension in adolescents using a meta-analysis

SUBJECTS AND METHOD

1. Study Design

The meta-analysis was performed with the PRISMA flowchart using PubMed, Science Direct, Springer Link, and Google Scholar databases. The keywords used are (hypertension OR "High Blood Pressure") AND "BMI Status" AND (adolescent OR teenager) AND "cross sectional". There were 9 primary studies that met the inclusion criteria of this study. Data analysis was carried out using RevMan 5.3.

2. Steps of Meta-Analysis

Meta-analysis is carried out through 5 steps as follows:

1) Formulate research questions with the PICO model (Population: adolescents aged 10 to 19 years, Intervention: overweight and obesity, Comparison: normoweight, and Outcome: hypertension).
2) Search for primary study research articles from 4 online databases, namely PubMed, Science Direct, Springer Link, and Google Scholar.
3) Conduct screening and quality assessment of primary articles.
4) Extracting and analyzing data using the RevMan 5.3 application.
5) Interpret the results and draw conclusions.

3. Inclusion Criteria

The article was in English, the research design used a cross-sectional design, the rela-

tionship size used was Odds Ratio (OR), the analysis used was multivariate with adjusted Odds Ratio (aOR), the research subjects were adolescents aged 10 to 19 years, the intervention was overweight and obesity, comparison in the form of normoweight, and the outcome variable is hypertension or high blood pressure.

4. Exclusion Criteria

Non full-text articles published before 2012 and after 2022.

5. Operational Definition of Variables

Overweight is the condition of being overweight in adolescents with a BMI value of more than 1 standard deviation above the WHO Growth Reference median or a BMI value between the 85th percentile and less than the 95th percentile according to the CDC Growth Chart (BMI equivalent to 25 to <30 kg /m2).

Obesity is a condition of being overweight in adolescents with a BMI value of more than 2 standard deviations above the WHO Growth Reference median or a BMI value at the 95th percentile or more according to the CDC Growth Chart (BMI equivalent to ≥30 kg/m2).

Hypertension is a condition when adolescent blood pressure is persistently elevated, namely at the 95th percentile or more (equivalent to ≥130/80 mmHg) on repeated measurements.

6. Study Instruments

The quality assessment of the primary articles in this study used a critical assessment checklist for cross-sectional studies published by the Joanna Briggs Institute (JBI).

7. Data Analysis

The articles were collected using PRISMA diagram and analyzed using the Review Manager 5.3 application (RevMan 5.3) by calculating the effect size and heterogeneity (I^2) to determine the combined research model and form the final results of the meta-analysis. The results of data analysis are presented in the form of forest plots and funnel plots.

RESULTS

The process of searching for primary articles related to the effect of overweight and obesity on the incidence of hypertension in adolescents in this meta-analysis study was carried out on 4 online databases and the results obtained were 9 articles which can be seen in Figure 1. PRISMA flow diagram.

The total articles in the initial search process were 1,553 articles with details of 4 articles from the PubMed database, 78 articles from the Science Direct database, 101 articles from the Springer Link database, and 633 articles from the Google Scholar database. Furthermore, 425 articles were deleted with duplicate articles and 1,128 articles were filtered. From a total of 550 eligible full text articles, 9 were included in the synthesis meta-analysis. Full text articles included in the exclusion criteria are due to the following reasons:

1) Outcomes and interventions from the study did not match the PICO criteria.
2) The research subjects are not teenagers aged 10-19 years, but include those aged less than 10 years or more than 19 years.
3) Does not include the value of the adjusted odds ratio (aOR) as a result of multivariate logistic regression analysis.
4) The study design is not cross sectional.
5) The operational definitions of the variables hypertension, overweight and obesity do not match the operational definitions of these variables in this study.

Figure 2. shows the distribution area of the primary articles used in this study which are spread over 3 continents, namely 5 articles from the Asian Continent (China, South Korea, Turkey), 2 articles from the African Continent (Tunisia), and 2 articles from the Continent Europe (Lithuania and Poland).

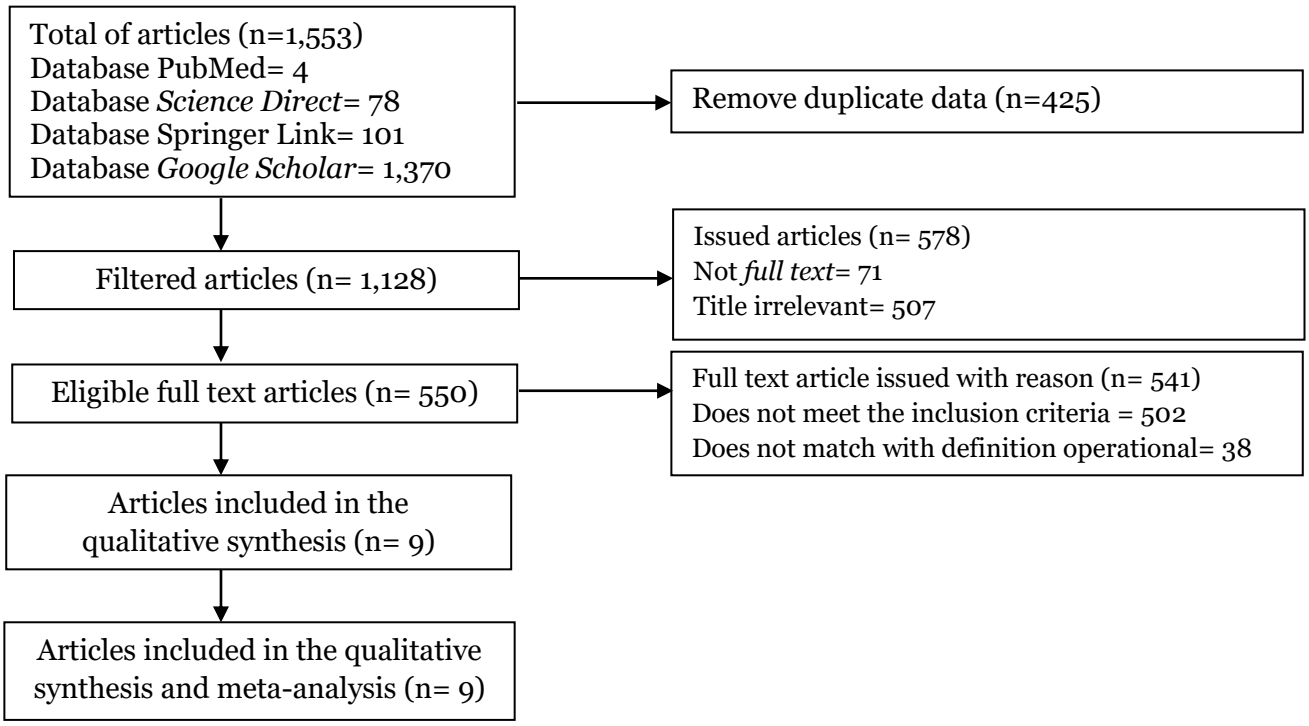

Figure 1. PRISMA Flow Diagram

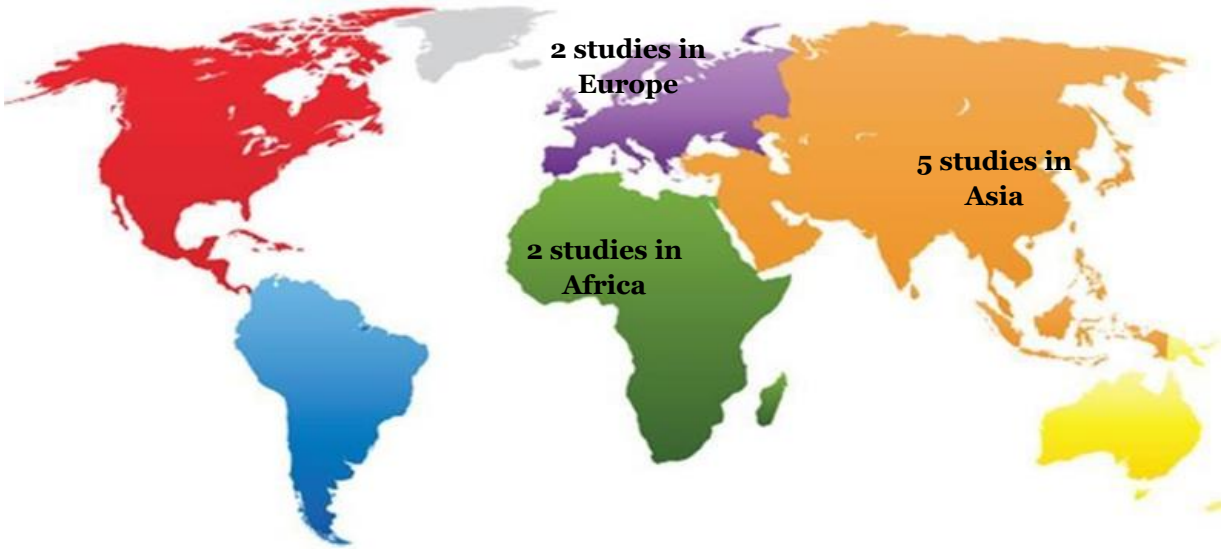

Figure 2. Map of research areas on the effect of overweight and obesity on hypertension in Adolescent

Table 1. shows the results of the primary study quality assessment used in this study. The assessment of the quality of the primary studies in this study was carried out using a critical appraisal checklist cross sectional study by JBI (Joanna Briggs Institute, 2017). Based on the results obtained from the study quality assessment, the total scores in the 9 selected primary studies ranged from 15 to 16, this indicates that the quality of all primary articles used in this study is feasible for meta-analysis.

Table 2. presents a description of the 9 primary studies with a cross-sectional study design that were included in the meta-analysis of the effects of overweight and obesity

on the incidence of hypertension in adolescents. There are 9 articles with a total sample of 63,239 youth aged 10 to 19 years.

Table 1. Critical appraisal checklist for cross-sectional study of the effect of overweight and obesity on the incidence of hypertension in adolescents

Author (Year)	Question Criteria								
	1	2	3	4	5	6	7	8	Total
Aounallah-Skhiri et al. (2012)	2	2	2	2	2	2	2	2	16
Cam et al. (2020)	2	2	2	2	1	2	2	2	15
Dulskiene et al. (2014)	2	2	2	2	2	2	2	2	16
Huang et al. (2022)	2	2	2	2	2	2	2	2	16
Kaczmarek et al. (2015)	2	2	2	2	2	2	2	2	16
Lim et al. (2014)	2	2	2	2	2	2	2	2	16
Liu et al. (2021)	2	2	2	2	2	2	2	2	16
Soua et al. (2022)	2	2	2	2	2	2	2	2	16
Zou et al. (2019)	2	2	2	2	1	2	2	2	15

Description of the question criteria:

1 = Were the criteria for inclusion in the sample clearly defined?
2 = Were the research subjects and settings described in detail?
3 = Is exposure measured in a valid and reliable way?
4 = What are the standard criteria used for objective condition measurement?
5 = Were confounding factors identified?
6 = Was a strategy for dealing with confounding factors stated?
7 = Are the results measured in a valid and reliable way?
8 = Has proper statistical analysis been used?

Answer score description:

0 = No
1 = Can't tell
2 = Yes

Table 2. Cross-sectional studies included for meta-analysis: the effect of overweight and obesity on the incidence of hypertension in adolescents (N=63,239)

Author (Year)	Country	Sample	P	I	C	O
Aounallah-Skhiri *et al.* (2012)	Tunis	1,484	Adolescent girls aged 15-19 years	Overweight, Obesity	Normo-weight	Hyper-tension
Cam *et al.* (2020)	Turkey	896	Teenagers aged 14-19 years	Overweight, Obesity	Normo-weight	Hyper-tension
Dulskiene et al. (2014)	Lithuania	7,457	Teens aged 12-15 years	Overweight, Obesity	Normo-weight	Hyper-tension
Huang et al. (2022)	China	886	Teens aged 11-14 years	Overweight, Obesity	Normo-weight	Hyper-tension
Kaczmarek et al. (2015)	Poland	4,941	Teenagers aged 10-18 years	Overweight, Obesity	Normo-weight	Hyperten sion
Lim et al. (2014)	South Korea	1,526	Teenagers aged 10-19 years	Overweight, Obesity	Normo-weight	Hyper-tension
Liu *et al.* (2021)	China	42,025	Teenagers aged 12-17 years	Overweight, Obesity	Normo-weight	Hyper-tension
Soua et al. (2022)	Tunis	1,385	Teenagers aged 14-19 years	Overweight, Obesity	Normo-weight	Hyper-tension
Zou et al. (2019)	China	2,639	Teens aged 12-15 years	Overweight, Obesity	Normo-weight	Hyper-tension

Table 3. Adjusted Odds Ratio (aOR) of primary studies included in the meta-analysis of the effect of overweight and obesity on the incidence of hypertension in adolescents

Studies	Overweight			Obesity		
	aOR	95%CI		aOR	95%CI	
		Lower Limit	Upper Limit		Lower Limit	Upper Limit
Aounallah-Skhiri et al. (2012)	2.1	1.0	4.3	5.4	2.2	13.4
Cam et al. (2020)	3.21	1.72	5.98	13.54	6.40	28.62
Dulskiene et al. (2014)	3.56	3.02	4.19	6.64	4.65	9.49
Huang et al. (2022)	5.73	3.27	10.03	2.33	1.54	3.52
Kaczmarek et al. (2015)	3.12	2.63	3.71	9.75	6.91	13.75
Lim et al. (2014)	1.46	0.94	2.28	1.90	1.05	3.45
Liu et al. (2021)	2.21	1.78	2.75	3.09	2.33	4.08
Soua et al. (2022)	1.72	1.18	2.51	3.74	2.56	5.42
Zou et al. (2019)	1.42	1.06	1.90	4.03	2.83	5.74

The forest plot in Figure 3. shows that there is an effect of overweight on hypertension in adolescents, and this effect is statistically significant. Overweight adolescents are 2.44 times more likely to experience hypertension compared to adolescents with normal weight (aOR= 2.44; 95%CI= 1.87 to 3.19; p<0.001). The forest plots also show high heterogeneity in the estimated effects of overweight between primary studies in this meta-analysis (I^2= 86%; p<0.001). Thus, the calculation of effect estimation is carried out using the Random Effect Model (REM) approach.

The funnel plot in Figure 4. shows that the distribution of effect estimates between studies is more or less symmetrical, that is, the distribution of effect estimates to the right and left of the vertical line of the average effect estimates is the same. Thus, this funnel plot shows no publication bias.

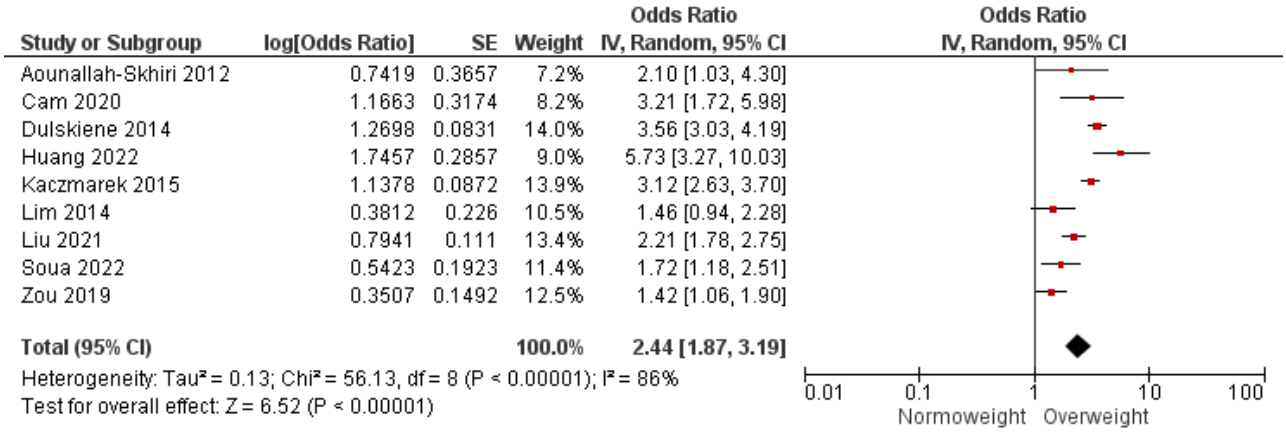

Figure 3. Forest plot meta-analysis of the effect of overweight on the incidence of hypertension

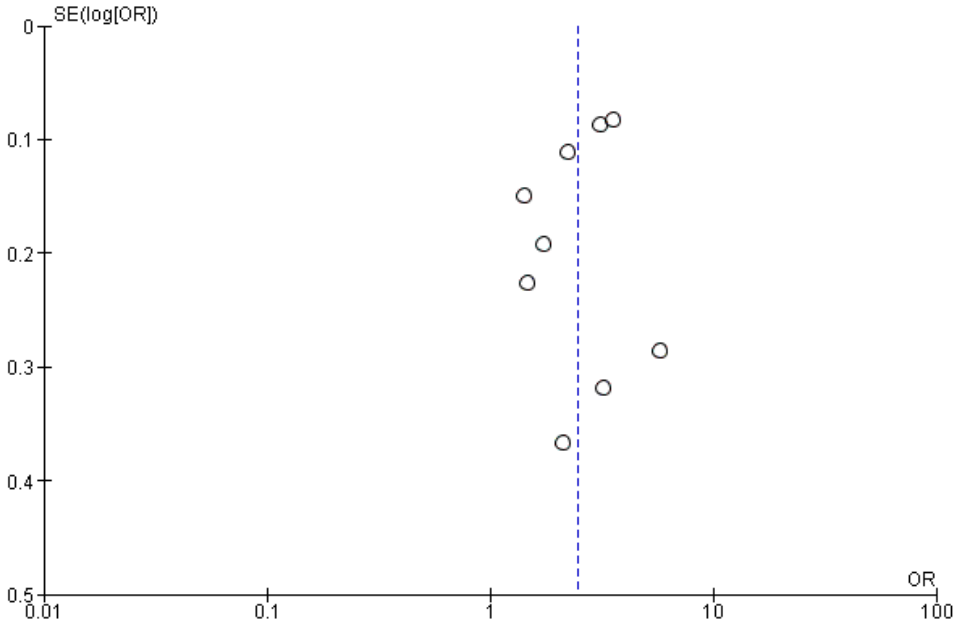

Figure 4. Funnel plot meta-analysis of the effect of overweight on the incidence of hypertension

The forest plot in Figure 5. shows that there is an effect of obesity on the incidence of hypertension in adolescents, and this effect is statistically significant. Obese adolescents are 4.53 times more likely to experience hypertension compared to adolescents with normal weight (aOR= 4.53; 95% CI= 3.10 to 6.61; p <0.001). The forest plots also show high heterogeneity in obesity effect estimates between primary studies in this meta-analysis (I^2= 86%; p<0.001). Thus, the calculation of effect estimation is carried out using the Random Effect Model (REM) approach.

The funnel plot in Figure 6. shows that the distribution of effect estimates between studies is more or less symmetrical, that is, the distribution of effect estimates to the right and left of the vertical line of the average effect estimates is the same. Thus, this funnel plot shows no publication bias.

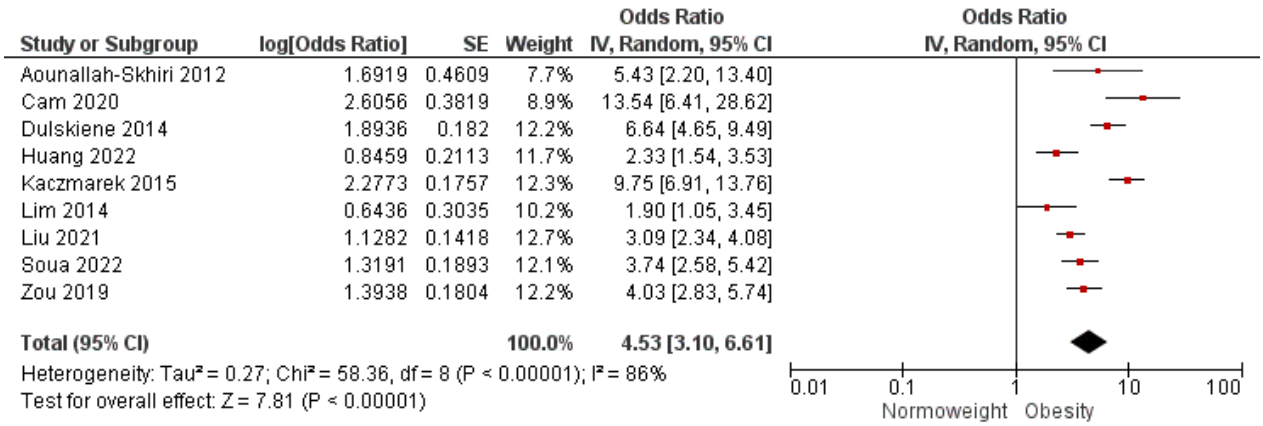

Figure 5. Forest plot meta-analysis of the effect of obesity on the incidence of hypertension

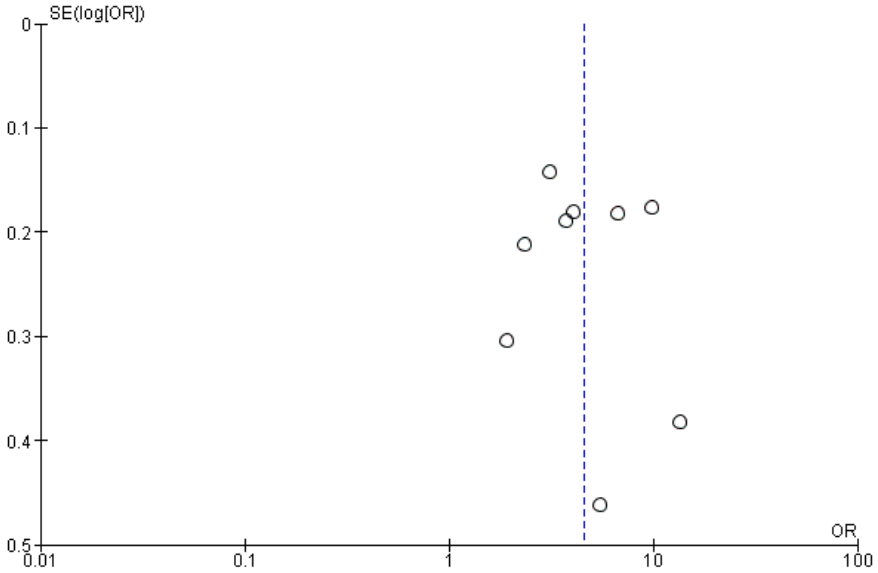

Figure 6. Funnel plot meta-analysis of the effect of obesity on the incidence of hypertension

DISCUSSION

1. Effect of overweight on the incidence of hypertension in adolescents

Overweight is defined as a condition of adolescent body weight that is more than 1 standard deviation above the WHO Growth Reference median (BMI equivalent to 25 to <30 kg/m2) or a BMI value between the 85th percentile and less than the 95th percentile based on CDC Growth Charts (CDC, 2021; WHO, 2021b). The condition of overweight in adolescents has the potential to cause various other health problems such as hypertension, which in turn can have long-term implications for the development of cardiovascular disease as adults (Flynn, 2019; Rohkuswara and Syarif, 2017).

Based on the results of a meta-analysis of 9 primary studies in this study, it showed that overweight adolescents were 2.44 times more likely to experience hypertension compared to adolescents with normal weight (aOR= 2.44; 95%CI= 1.87 to 3.19; p<0.001).

The results of this study are in line with research by Manios et al. (2017) which shows that being overweight or overweight in adolescents is significantly related to hypertension in both conditions of increased systolic and diastolic blood pressure. Adolescents with excess body weight have a 2.51 times more likely to have an increase in systolic or diastolic blood pressure compared to adolescents with normal or underweight weight (aOR = 2.51; 95% CI= 1.97 to 3.20).

Research by Szabo et al. (2021) also showed similar results, namely the percentage of hypertension in both male and female adolescents was higher in those who were overweight (64.14%) compared to adolescents with normal weight. The results of this study also show that increasing body weight is a significant risk factor for the incidence of hypertension in adolescents.

The results of other studies show that there is a strong relationship between overweight and hypertension in adolescents (Wariri et al., 2018). According to Yusrizal et al. (2016), BMI values and the risk of hypertension in adolescents show a positive relationship, which means that any increase in BMI values will be followed by an increased risk of hypertension in adolescents. The results of this study indicate that every 1

kg/m2 increase in BMI can increase the risk of hypertension in adolescents by 4.85 mmHg.

The results obtained in this meta-analysis show that adolescents who are overweight are more likely to develop hypertension, but the exact size of the effect varies. This shows the possibility that there are other factors that influence hypertension in overweight adolescents.

According to Kelly et al. (2015), in general there are a number of characteristics that are identified as increasing the risk of hypertension in overweight adolescents, but the underlying biological mechanisms are uncertain. Several factors that have been identified to increase the risk of hypertension in overweight adolescents include a history of hypertension and a history of diabetes mellitus in the family, older age, history of LBW (low birth weight), lack of physical activity, poor sleep quality, excess sodium intake. , and lack of potassium intake.

2. The effect of obesity on the incidence of hypertension in adolescents

Obesity is defined as an adolescent whose body weight is more than 2 standard deviations above the WHO Growth Reference median (BMI equivalent to ≥30 kg/m2) or a BMI value at the 95th percentile or more according to the CDC Growth Charts (CDC, 2021; WHO, 2021b). Obesity shows a condition of body weight that exceeds the condition of being overweight, so that adolescents with obesity have a greater possibility of experiencing other, more serious health problems, such as hypertension, and can also trigger the development of cardiovascular disease as adults (Flynn, 2019; Rohkuswara and Syarif, 2017).

The results of this study's meta-analysis showed that obese adolescents were 4.53 times more likely to experience hypertension compared to adolescents with normal weight (aOR= 4.53; 95% CI= 3.10 to 6.61; p<0.001).

The results of this study are in line with the research of Manios et al. (2017) that obesity in adolescents is significantly related to hypertension both in conditions of increased systolic and diastolic blood pressure. Obese adolescents are 6.31 times more likely to have an increase in systolic or diastolic blood pressure than adolescents with normal weight or less (aOR = 6.31; 95% CI = 4.62 to 8.60).

Meanwhile, similar to the research by Febriani et al. (2020) which showed that obesity can increase the risk of hypertension in adolescents and the effect is statistically significant (OR = 5.8; p<0.001). The results of this study also show that obesity, a family history of hypertension and a family history of obesity can simultaneously increase the risk of hypertension in adolescents.

The results of several studies show that the risk of hypertension in obese adolescents is higher than the risk of hypertension in overweight adolescents, with a reference for the size of the effect being adolescents with normal nutritional status or normoweight (Manios et al., 2017; Mohan et al., 2019) . This is consistent with the results of this meta-analysis study which showed that the effect size of obesity on hypertension in adolescents was higher (aOR = 4.53) than the effect size of overweight on hypertension in adolescents (aOR = 2.44).

In line with this, Karimulla and Rao's research (2021) shows a positive relationship between BMI and hypertension, which means that the higher the BMI value, the greater the risk of hypertension, and in this case the BMI obesity value range is higher than the BMI value range for the category overweight. According to Brady (2017), the main approach in dealing with the problem of adolescents with obesity-related hypertension needs to be focused on achieving a healthy weight and achieving a healthy lifestyle.

This study has several limitations, such as a language bias because this research uses only primary studies published in English. In this study there were also limitations in searching for primary studies because researchers only searched 4 online databases, namely PubMed, Science Direct, Springer Link, and Google Scholar.

AUTHOR CONTRIBUTION

Nurussyifa Afiana Zaen as the main researcher who selects topics, conducts searches for research data collection, and conducts research data analysis. Didik Gunawan Tamtomo and Burhannudin Ichsan reviewed research documents.

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CONFLICT OF INTEREST

There is no conflict of interest in this study.

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