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Masters Program in Public Health, Universitas Sebelas Maret

Meta-Analysis

# Effects of Physical Activity, Fruit and Vegetables Intake, and Alcohol Consumption on Overweight or Obesity: Meta-Analysis

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## ABSTRACT

**Background:** Overweight or obesity is a public health problem worldwide which is increasing both in the general population and in people with chronic diseases. Over-all both children and adults are vulnerable to overweight or obesity. This study aims to examine the effect of physical activity, consumption of vegetables and alcohol on overweight or obesity using a meta-analysis.
**Subjects and Method:** Meta-analysis was carried out using the PRISMA flowchart and the PICO model. Population: age 6 to 64 years. Intervention: low physical activity, low vegetable and fruit consumption, and high alcohol. Comparison: high physical activity, high vegetable and fruit consumption, and alcohol low. Outcome: overweight or obese. The databases used are Google Scholar, PubMed, and Proquest with keywords (Overweight OR Obesity OR "BMI Status") AND (“Physical Activity” OR Exercise OR Sport OR Inactive) AND (Vegetable AND Fruit) AND Alcohol AND "Cross Sectional" AND aOR. There were 22 cross-sectional studies published in 2012-2022 that met the inclusion criteria. Analysis was performed with RevMan 5.3.
**Results:** A meta-analysis was conducted on 22 articles with a cross-sectional study design originating from Indonesia, Ghana, Arab Emirates, Texas, Ethiopia, Uganda, Botswana, Congo, Bahir Dar, North Western, Toronto, Zambia, Cameroon and Tanzania involving 91,031 ages 6-64 years. The results of the meta-analysis showed that someone with low physical activity had a risk of being overweight or obese 1.35 times compared to high physical activity (aOR= 1.35; 95% CI= 1.09 to 1.68; p<0.001), someone with high consumption of vegetables and fruit have a risk of experiencing overweight or obesity 1.40 times compared to high consumption of vegetables and fruits (aOR= 1.40; 95%CI= 0.94 to 2.08; p<0.001), and someone with high alcohol has a risk of experiencing overweight or obesity 1.47 times compared low alcohol (aOR= 1.47; 95% CI= 1.31 to 1.65; p<0.001).
**Conclusion:** Low vegetable and fruit consumption, high alcohol consumption and low physical activity can increase the risk of being overweight or obese.

**Keywords:** social support, self-efficacy, social cognitive theory, hypertension, medication adherence

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## BACKGROUND

Overweight or obesity as a multifactorial disease, chronic, recurrent, and a risk factor for other non-communicable diseases such as diabetes, cardiovascular disease, various cancers, and so on (WOF,2022). Overweight or obesity can also increase the risk of depression and affect other mental health conditions, and can even pose a risk of death (Anstey et al., 2011; Dai et al., 2020).

From 1975 to 2016, obesity has nearly tripled. In 2016, the number of overweight sufferers reached 1.9 billion adults aged 18 years and over and of these, the number of obese people was recorded at more than 650 million people (Ladhani et al., 2017; WHO, 2021). Worldwide, 2.8 million people die each year as a result of being overweight or obese, and an estimated 35.8 million (2.3%) of global Disability-Adjusted Life Years (DALY) are caused by overweight or obesity (WHO, 2022). The increase in obesity in children is more than tenfold, which is estimated from 11 million to 124 million, and as many as 216 million children are classified as overweight (WOF, 2022).

Just like other chronic diseases, obesity has many risk factors that interact with each other. Several previous studies stated that the risk factors for obesity include genetic factors, individual behavioral factors including physical activity, vegetable and fruit consumption, alcohol consumption, socioeconomic factors including income and education, and environmental factors including sociodemographics, access to health service, social culture, availability processed products or fast-food restaurants (Sheikh et al., 2022; Hruby and Hu, 2016).

Lack of physical activity is a major risk factor for overweight or obesity, because it will affect the balance of energy intake and expenditure (Mayulu, 2013; Sudikno et al., 2010). Quoted from The Physical Activity Guidelines for Americans, physical activity promotes normal growth and development, sleeps better, and reduces the risk of a number of chronic diseases including being overweight or obese. Adults should engage in moderate-intensity physical activity for at least 150 minutes to 300 minutes a week, or vigorous-intensity aerobic activity for at least 75 minutes to 150 minutes a week, or also be able to engage in physical activity a combination of both moderate and vigorous intensity physical activity (HHS, 2018).

Excessive alcohol use can lead to the development of chronic diseases and other serious problems including being overweight or obese. Conversely, not consuming excessive alcohol can reduce the risk of short-term and long-term health problems (CDC, 2022).

In this study, researchers were interested in compiling a systematic review and meta-analysis regarding "The effect of physical activity, consumption of vegetables and fruit, and alcohol on overweight or obesity". This study aims to examine the effect of physical activity, consumption of vegetables and alcohol on overweight or obesity using a meta-analysis.

## SUBJECTS AND METHOD

### 1. Study Design

The meta-analysis was carried out using the PRISMA flowchart using the Google Scholar, PubMed, and Proquest databases. The keywords used are (Overweight OR Obesity OR "BMI Status") AND ("Physical Activity" OR Exercise OR Sport OR Inactive) AND (Vegetable AND Fruit) AND Alcohol AND "Cross Sectional" AND aOR. There were 22 primary studies that met the inclusion criteria of this study. Data analysis was performed with RevMan 5.3.

### 2. Steps of Meta-Analysis

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

1) Formulate research questions following PICO model. Population: age 6 to 64 years. Intervention: low physical activity, low vegetable and fruit consumption, and high alcohol. Comparison: high physical activity, high consumption of vegetables and fruit, and low alcohol. Outcome: overweight or obese.

2) Search for primary study research articles from 3 online databases, namely Google Scholar, PubMed, and Pro-quest.
3) Conduct screening and quality assessment of primary research articles.
4) Extracting and analyzing data into the RevMan 5.3 application.
5) Interpret the results and draw conclusions.

**3. Inclusion Criteria**

Full-paper article using cross sectional design. The analysis used is multivariate with adjusted odds ratio (aOR). The research subjects were children aged 6 years to adults aged 64 years. The intervention is physical activity, consumption of vegetables and fruit, alcohol. The research outcome is overweight and or obesity.

**4. Exclusion Criteria**

Exclusion criteria were articles non-English languages and articles published before 2012 and after 2022.

**5. Operational Definition of Variables**

**Physical activity** is activities that include physical activity, both light, moderate and heavy intensity expressed in the form of frequency per day.

**The consumption of vegetables and fruit** is the consumption habits of vegetables and fruit expressed in the form of frequency of eating <5 times or ≥5 times day.

**Alcohol consumption** is the habit of using alcohol in the form of drinking frequency > 1 glass or ≤ 1 glass per day.

**Overweight or obesity** is the condition of being overweight with a BMI value in adults equivalent to > 25 kg/m2 for overweight or > 30 kg/m2 for obesity, and in children equivalent to > +1 SD for overweight or > +2 SD for obesity.

**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 in this study were collected using the 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 physical activity, consumption of vegetables and fruit, and alcohol on overweight or obesity in this meta-analysis study was carried out on 3 online databases and the results obtained were 22 articles which can be seen in Figure 1. PRISMA Flow Diagram.

The total articles in the initial search process were 10,445 articles with details of 9,200 articles from the Google Scholar database, 11 articles from the PubMed database, 1,234 articles from the Proquest database. Then, 1,009 articles were deleted and 993 articles were filtered. From a total of 216 eligible full-text articles, 22 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 or formula in this study.
2) The research subjects were not aged 6 to 64 years, but included ages less than 6 years or more than 64 years.
3) Does not include the adjusted odds ratio (aOR) as the result of multivariate logistic regression analysis.
4) Study design other than cross sectional
5) The operational definitions of the variables of physical activity, vegetable and fruit consumption, alcohol, overweight or

obesity do not match the operational definitions of these variables in this study.

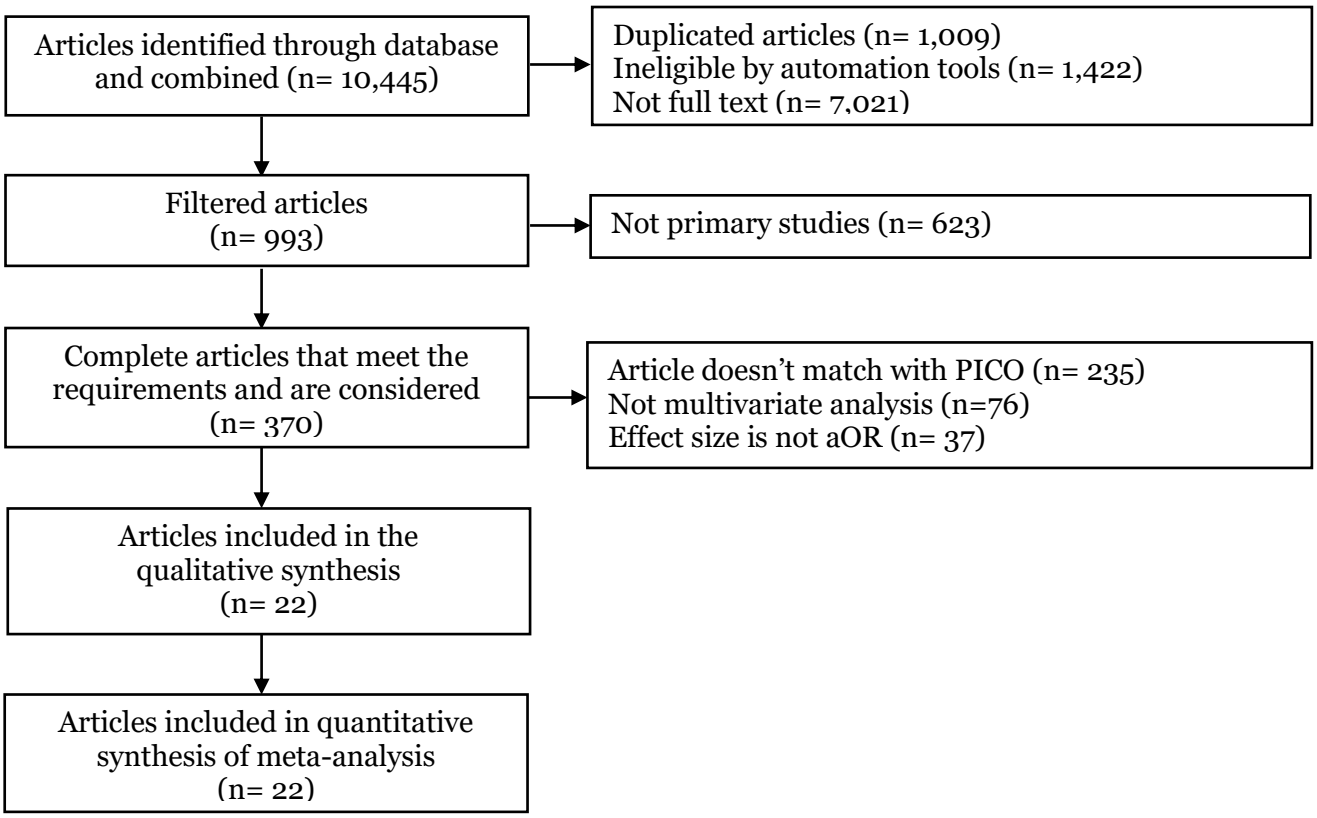


**Figure 1. PRISMA Flowchart**

Figure 2 shows the distribution area of the primary articles used in this study which are spread over 3 continents, namely 2 articles from the Asian Continent (Indonesia, Arab Emirates), 2 articles from the Americas (Toronto, Texas), and 18 articles from the African Continent (Cameroon, Zambia, Bahir Dar, North Western, Ghana, Ethiopia, Botswana, Uganda, Tanzania, Congo).


**Figure 2. Map of the study area on the effects of physical activity, fruit and vegetables intake, and alcohol consumption on overweight or obesity**

Table 1 shows the results of the primary study quality assessment used in this study. 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 22 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 1. Critical appraisal checklist for cross sectional study the effect of physical activity, consumption of vegetables and fruit, and alcohol on overweight or obesity**

| Author | Question Criteria | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
| Arfines et al. (2020) | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 15 |
| Aryeetey et al. (2017) | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 16 |
| Besa et al. (2013) | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 15 |
| Baniissa et al. (2020) | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 16 |
| Bejarano et al. (2022) | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 15 |
| Bogale & Zewale (2019) | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 16 |
| Dagne et al. (2019) | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 16 |
| Darebo et al. (2019) | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 16 |
| Fikre et al. (2022) | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 16 |
| Kabwama et al. (2018) | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 16 |
| Keetile et al. (2019) | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 16 |
| Mawaw et al. (2017) | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 16 |
| Mekonnen et al.(2018a) | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 16 |
| Mekonnen et al. (2018b) | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 15 |
| Menon et al. (2019) | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 16 |
| Mogre et al. (2015) | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 16 |
| Rudatsikira et al. (2012) | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 16 |
| Simo et al. (2021) | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 16 |
| Tateyama et al. (2018) | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 16 |
| Tekalegn et al. (2022) | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 15 |
| Tesfaye et al. (2020) | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 16 |
| Zubery et al. (2021) | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 16 |

**Description of the question criteria:**

1 = Are the criteria included in the sample clearly defined?
2 = Are the research subjects and settings explained in detail?
3 = Is exposure measured in a valid and reliable way?
4 = What are the standard criteria used for measuring objective conditions?
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 = Was proper statistical analysis used?

**Answer score description:**

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

Table 2 presents descriptions of 22 primary studies with cross-sectional study designs that were included in the meta-analysis of the effect of physical activity, consumption of vegetables and fruits, and alcohol on overweight or obesity. There are 22 articles with a total sample of 92,229 people aged 6 to 64 years.

**Table 2. Description of primary cross-sectional study included in the meta-analysis of the effect of physical activity, consumption of vegetables and fruit, and alcohol on overweight or obesity (N=92,229)**

| Author | Country | Sample | P | I | C | O |
|---|---|---|---|---|---|---|
| Arfines et al. (2020) | Indonesia | 3,116 | Age ≤ 18 years | Low physical activity (<60 minutes/day), high alcohol (>1 drink/day) | High physical activity (≥60 minutes/day), low alcohol (≤1 glass/ day) | Overweight or obesity |
| Aryeetey et al. (2017) | Ghana | 3,089 | Age 9 to 15 years | Low physical activity (<60 minutes/day) | High physical activity (≥60 minutes/day) | Overweight or obesity |
| Baniissa et al. (2020) | Arab Emirates | 932 | Age 13 to 19 years | Low physical activity (<60 minutes/day), low consumption of vegetables and fruit (<5 times/day) | High physical activity (≥60 minutes/day), high consumption of vegetables and fruit (≥5 times/day) | Overweight or obesity |
| Bejarano et al. (2022) | Texas | 58,561 | Age 7 to 9 years | Low physical activity (<60 minutes/day) | High physical activity (≥60 minutes/day) | Overweight or obesity |
| Bogale and Zewale (2019) | Zambia | 1,198 | Age ≥ 24 years | High alcohol (> 1 glass / day) | Low alcohol (≤1 drink/day) | Overweight or obesity |
| Dagne et al. (2019) | Ethiopia | 1,915 | Age ≥ 25 years | Low physical activity (<60 minutes/day), high alcohol (>1 drink/day) | High physical activity (≥60 minutes/day), low alcohol (≤1 glass/ day) | Overweight or obesity |
| Darebo et al. (2019) | Ethiopia | 751 | Age 18 to 64 years | Low physical activity (<60 minutes/day), high alcohol (>1 drink/day) | High physical activity (≥60 minutes/day), low alcohol (≤1 glass/ day) | Overweight or obesity |
| Fikre et al. (2022) | Ethiopia | 531 | Age 18-64 years | Low physical activity (<60 minutes/day), high alcohol (>1 drink/day) | High physical activity (≥60 minutes/day), low alcohol (≤1 glass/ day) | Overweight or obesity |
| Kabwama et al. (2018) | Ethiopia | 524 | Age ≥ 18 years | Low physical activity (<60 minutes/day), high alcohol (>1 drink/day) | High physical activity (≥60 minutes/day), low alcohol (≤1 glass/ day) | Overweight or obesity |
| Keetile et al. (2019) | Bostwana | 1,178 | Age ≥ 24 years | Low physical activity (<60 minutes/day), low consumption of vegetables and fruit (<5 times/day), high alcohol (>1 glass/day) | High physical activity (≥60 minutes/day), high consumption of vegetables and fruit (≥5 times/day), low alcohol (≤1 glass/day) | Overweight or obesity |
| Mawaw et al. (2017) | Kongo | 430 | Age ≥ 20 years | Low physical activity (<60 minutes/day), high alcohol (>1 drink/day) | High physical activity (≥60 minutes/day), low alcohol (≤1 glass/day) | Overweight or obesity |
| Mekonnen (2018a) | Bahir Dar | 634 | Age 6 to 12 years | Low physical activity (<60 minutes/day), low consumption of vegetables and fruit (<5 times/day) | High physical activity (≥60 minutes/day), high consumption of vegetables and fruit (≥5 times/day) | Overweight or obesity |
| Mekonnen et al. (2018b) | North Western | 524 | Age ≥ 18 years | Low physical activity (<60 minutes/day), low consumption of vegetables and fruit (<5 times/day) | High physical activity (≥60 minutes/day), high consumption of vegetables and fruit (≥5 times/day) | Overweight or obesity |

| Author | Country | Sample | P | I | C | O |
|---|---|---|---|---|---|---|
| Menon et al. (2019) | Toronto | 9,866 | Age 11 to 17 years | Low physical activity (<60 minutes/day), low consumption of vegetables and fruit (<5 times/day) | High physical activity (≥60 minutes/day), high consumption of vegetables and fruit (≥5 times/day) | Overweight or obesity |
| Mogre et al. (2015) | Ghana | 552 | Age 18 to 36 years | Low physical activity (<60 minutes/day), low consumption of vegetables and fruit (<5 times/day), high alcohol (>1 glass/ day) | High physical activity (≥60 minutes/day), high consumption of vegetables and fruit (≥5 times/day), low alcohol (≤1 glass/day) | Overweight or obesity |
| Rudatsikira et al. (2012) | Zambia | 1,915 | Age ≥ 25 years | Low physical activity (<60 minutes/day), high alcohol (>1 drink/day) | High physical activity (≥60 minutes/day), low alcohol (≤1 glass/day) | Overweight or obesity |
| Besa et al. (2013) | Zambia | 1,198 | Age ≥ 24 years | High alcohol (> 1 glass / day) | Low alcohol (≤1 drink/day) | Overweight or obesity |
| Simo et al. (2021) | Cameroon | 485 | Age ≥ 18 years | Low physical activity (<60 minutes/day), high alcohol (>1 drink/day) | High physical activity (≥60 minutes/day), low alcohol (≤1 glass/day) | Overweight or obesity |
| Tateyama et al. (2018) | Zambia | 690 | Age 25 to 64 years | Low physical activity (<60 minutes/day), low consumption of vegetables and fruit (<5 times/day), high alcohol (>1 glass/ day) | High physical activity (≥60 minutes/day), high consumption of vegetables and fruit (≥5 times/day), low alcohol (≤1 glass/day) | Overweight or obesity |
| Tekalegn et al. (2022) | Ethiopia | 694 | Age ≥18 years | Low physical activity (<60 minutes/day), low consumption of vegetables and fruit (<5 times/day) | High physical activity (≥60 minutes/day), high consumption of vegetables and fruit (≥5 times/day) | Overweight or obesity |
| Tesfaye et al. (2020) | Ethiopia | 663 | Age 18 to 64 years | Low physical activity (<60 minutes/day) | High physical activity (≥60 minutes/day) | Overweight or obesity |
| Zubery et al. (2021) | Tanzania | 305 | Age 18 to 60 years | Low physical activity (<60 minutes/day) | High physical activity (≥60 minutes/day) | Overweight or obesity |

Table 3, Table 4, and Table 5 presents descriptions of 22 primary studies with cross-sectional study designs that were included in the meta-analysis of the effect of physical activity, consumption of vegetables and fruits, and alcohol on overweight or obesity. There are 22 articles with a total sample of 92,229 people aged 6 to 64 years.

**Table 3. Adjusted Odds Ratio (aOR) effect of physical activity on overweight or obesity (N=92,229)**

| Author (Years) | AOR | CI 95% | |
|---|---|---|---|
| | | Upper | Lower |
| Arfines et al. (2020) | 0.89 | 0.77 | 1.03 |
| Aryeetey et al. (2017) | 1.44 | 1.07 | 1.94 |
| Baniissa et al. (2020) | 2.09 | 1.36 | 3.21 |
| Bejarano et al. (2022) | 0.76 | 0.50 | 1.16 |
| Bogale and Zewale (2019) | 2.42 | 1.36 | 4.31 |
| Dagne et al. (2019) | 1.16 | 0.18 | 7.47 |
| Darebo et al (2019) | 3.10 | 1.72 | 5.59 |
| Fikre et al (2022) | 2.96 | 1.55 | 5.65 |
| Kabwama et al. (2018) | 0.90 | 0.59 | 1.37 |
| Keetile et al. (2019) | 1.46 | 1.03 | 2.07 |
| Mawaw et al. (2017) | 4.04 | 0.88 | 18.55 |
| Mekonnen et al. (2018) | 2.87 | 1.21 | 6.81 |
| Mekonnen et al. (2018) | 0.61 | 0.37 | 1.01 |
| Menon et al. (2019) | 1.29 | 1.03 | 1.62 |
| Mogre et al. (2015) | 2.10 | 0.50 | 8.82 |
| Rudatsikira et al. (2012) | 0.72 | 0.41 | 1.26 |
| Simo et al. (2021) | 1.10 | 0.60 | 2.02 |
| Tateyama et al. (2018) | 0.56 | 0.23 | 1.36 |
| Tekalegn et al. (2022) | 0.84 | 0.55 | 1.28 |
| Tesfaye et al. (2020) | 2.68 | 1.70 | 4.22 |
| Zubery et al. (2021) | 1.98 | 0.69 | 5.68 |

**Table 4. Adjusted Odds Ratio (aOR) effect of alcohol activity on overweight or obesity (N=92,229)**

| Author (Years) | AOR | CI 95% | |
|---|---|---|---|
| | | Upper | Lower |
| Arfines et al. (2020) | 1.37 | 0.52 | 3.61 |
| Besa et al. (2013) | 1.49 | 1.25 | 1.78 |
| Bogale and Zewale (2019) | 2.27 | 1.23 | 4.19 |
| Dagne et al. (2019) | 1.75 | 1.04 | 2.94 |
| Darebo et al (2019) | 2.54 | 1.40 | 4.61 |
| Fikre et al (2022) | 2.23 | 1.30 | 3.84 |
| Kabwama et al. (2018) | 1.20 | 0.87 | 1.66 |
| Keetile et al. (2019) | 1.23 | 0.53 | 2.85 |
| Mawaw et al. (2017) | 1.97 | 0.89 | 4.36 |
| Mogre et al. (2015) | 8.20 | 2.20 | 30.56 |
| Rudatsikira et al. (2012) | 1.20 | 0.78 | 1.85 |
| Simo et al. (2021) | 1.21 | 0.76 | 1.93 |
| Tateyama et al. (2018) | 1.35 | 0.83 | 2.17 |

**Table 3. Adjusted Odds Ratio (aOR) effect of consumption vegetables and fruit on overweight or obesity (N=92,229)**

| Author (Years) | AOR | CI 95% | |
|---|---|---|---|
| | | Upper | Lower |
| Baniissa et al. (2020) | 2.41 | 1.73 | 3.36 |
| Kabwama et al. (2018) | 0.93 | 0.75 | 1.15 |
| Keetile et al. (2019) | 0.80 | 0.28 | 2.29 |
| Mekonnen et al. (2018a) | 6.45 | 3.19 | 13.04 |
| Mekonnen et al. (2018b) | 0.51 | 0.35 | 0.77 |
| Menon et al. (2019) | 1.08 | 0.88 | 1.33 |
| Mogre et al. (2015) | 2.60 | 1.20 | 5.63 |
| Tateyama et al. (2018) | 2.00 | 1.07 | 3.74 |
| Tekalegn et al. (2022) | 0.87 | 0.57 | 1.33 |

**The effect of Physical Activity on Overweight or Obesity**

The forest plot in Figure 3 shows that there is an effect of low physical activity on overweight or obesity, and this effect is statistically significant. Someone with low physical activity has a risk of being overweight or obese 1.35 times compared to someone with high physical activity (aOR=1.35; 95% CI 1.09 to 1.68; p=0.006). The forest plot also shows high heterogeneity effect estimates between primary studies with $I^2$= 78% (p<0.001). Thus, the calculation carried out with the Random Effect Model (REM).

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 average vertical line of effect estimates is relatively the same. Thus, this funnel plot indicates that there is no publication bias.

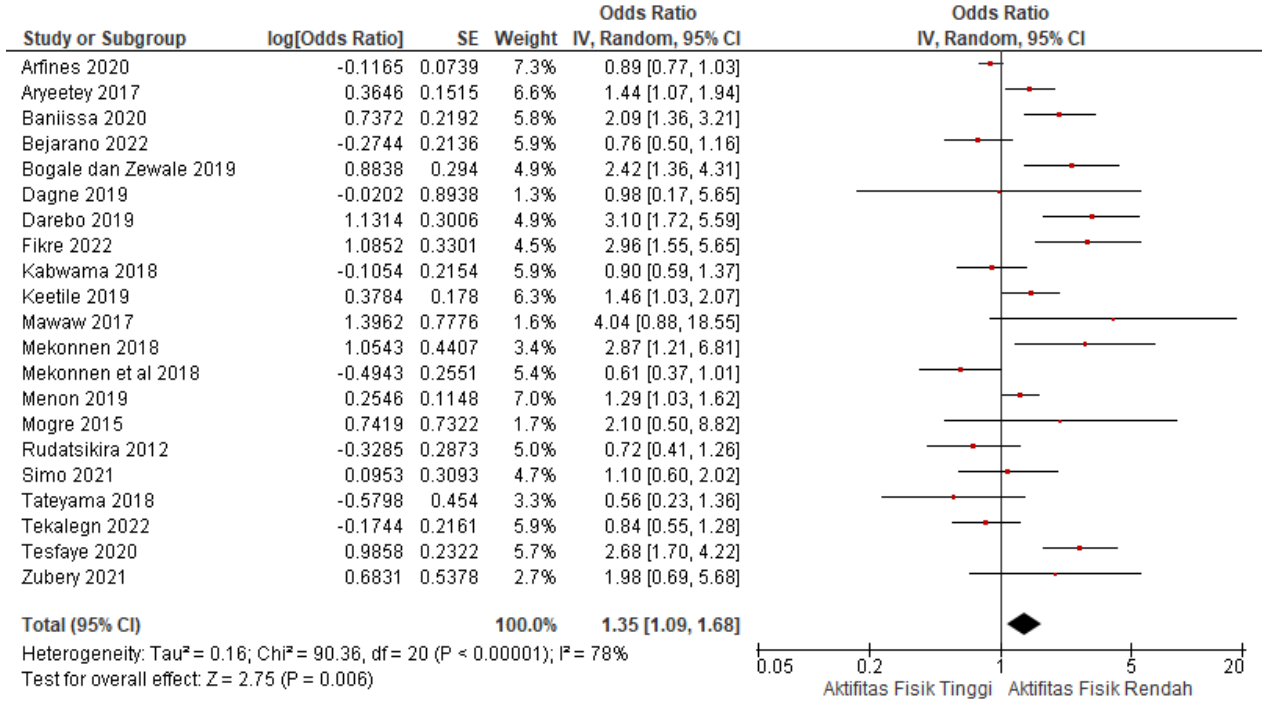


**Figure 3. Forest plot meta-analysis the effect of physical activity on overweight or obesity**

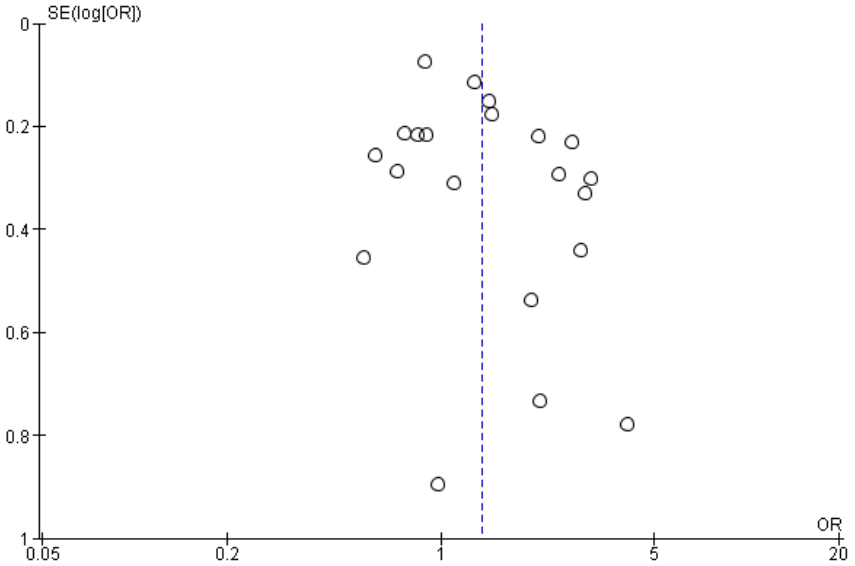


**Figure 4. Funnel plot meta-analysis the effect of physical activity on overweight or obesity**

### The effect of Alcohol on Overweight or Obesity

The forest plot in Figure 5 shows that there is an effect of alcohol on overweight or obesity, and this effect is statistically significant. People with high alcohol had a risk of being overweight or obese 1.47 times compared to someone with low alcohol (aOR= 1.47; 95% CI 1.31 to 1.65; p<0.001). The forest plot also shows low heterogeneity of effect estimates between primary studies with $I^2$ = 19% (p= 0.260). Thus, the calculation of effect estimation is carried out using the fixed effect model 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 or distribution of effect estimates to the right and left of the vertical line of the average effect estimates is relatively the same. Thus, this funnel plot indicates that there is no publication bias.

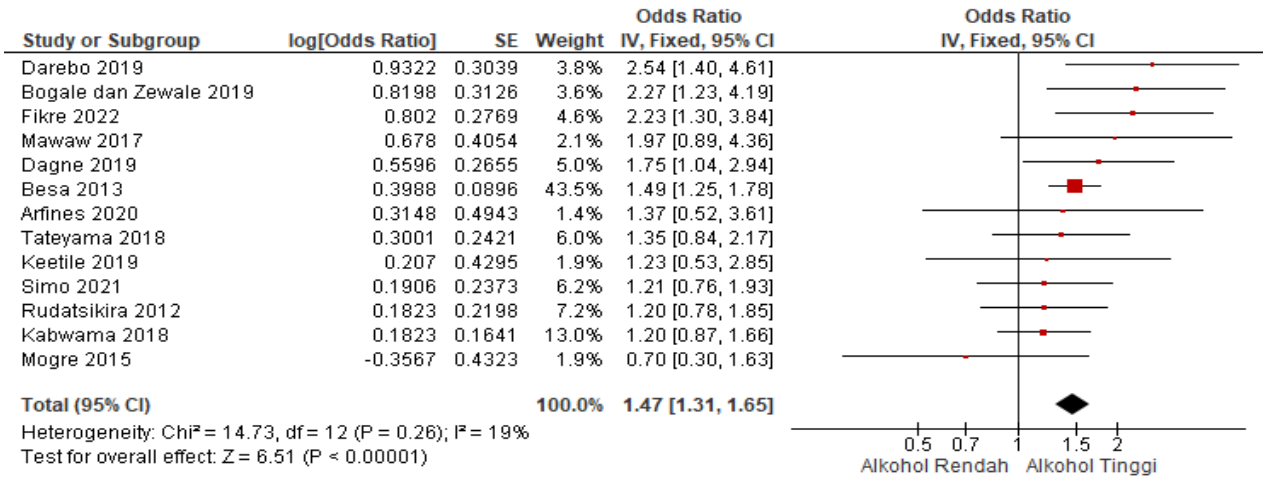


**Figure 5. Forest plot meta-analysis the effect of alcohol on overweight or obesity**

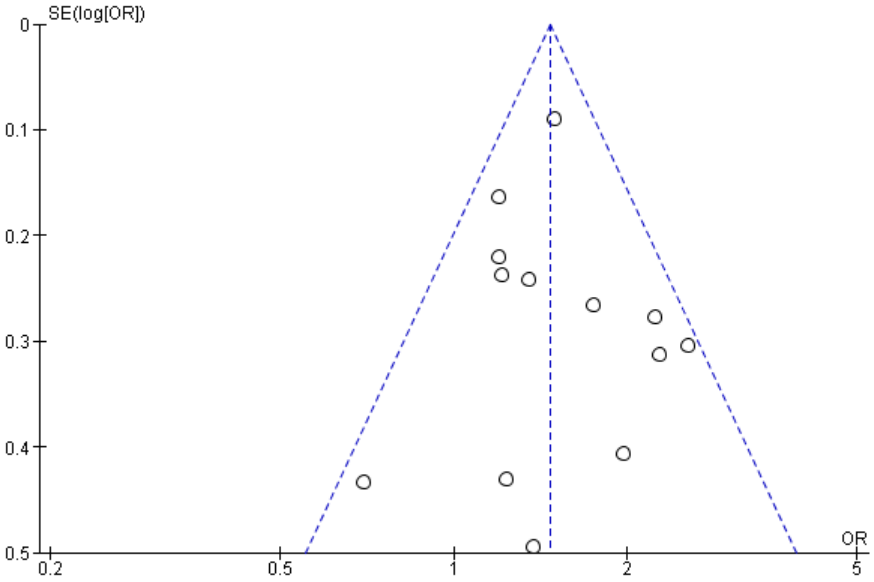


**Figure 6. Funnel plot meta-analysis the effect of alcohol on overweight or obesity**

**Effect of vegetable and fruit consumption on overweight or obesity**

The forest plot in Figure 7 shows that there is an effect of low vegetable and fruit consumption on overweight or obesity, and this effect is statistically close to significant. A person with low vegetable and fruit consumption has a risk of being overweight or obese 1.40 times compared to high vegetable and fruit consumption (aOR= 1.40; 95% CI= 0.94 to 2.08; p=0.090). The forest plot also shows high heterogeneity of effect estimates between primary studies with $I^2$ = 89% (p<0.001). Thus, the calculation of effect estimation is carried out using the Random Effect Model (REM) approach.

The funnel plot in Figure 8 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 average vertical line of effect estimates is relatively the same. Thus, this funnel plot indicates that there is no publication bias.

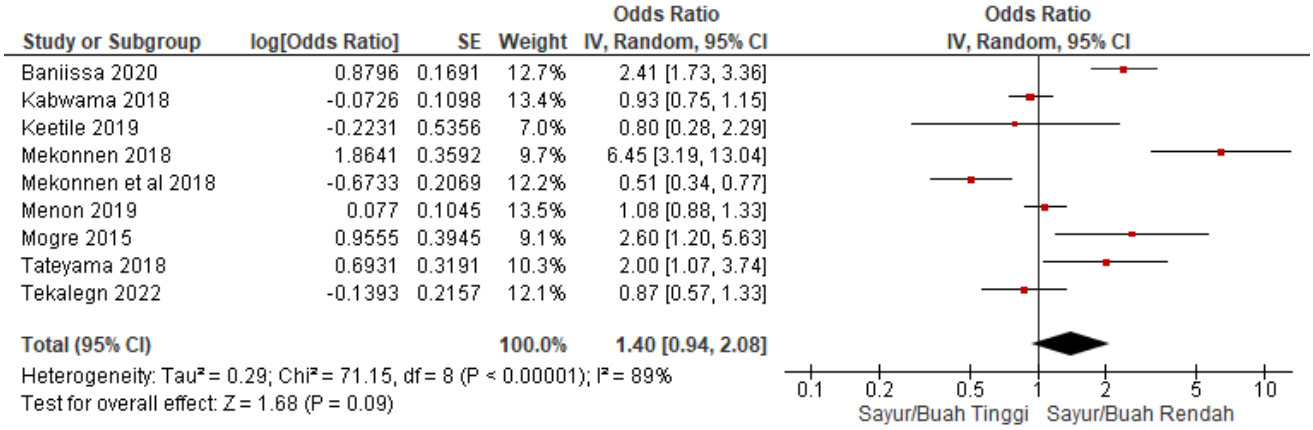


**Figure 7. Forest plot meta-analysis the effect of vegetables and fruit consumption on overweight or obesity**

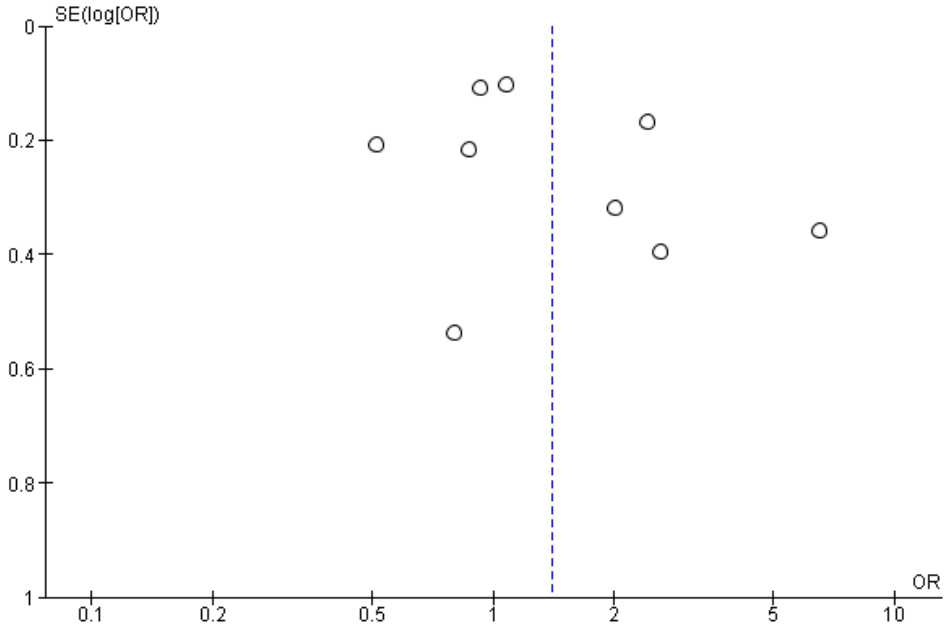


**Figure 8. Funnel plot meta-analysis the effect of vegetable and fruit consumption on overweight or obesity**

## DISCUSSION

### The effect of physical activity on Overweight or obesity

WHO in 2000 defined overweight or obesity as excessive accumulation of fat due to an imbalance between energy intake and energy expenditure in the long term (Kemenkes RI, 2015). Overweight is a condition of body weight with an obese body mass index of 25 kg/m2 or higher, and obesity of 30 kg/m2 or higher. Overweight children aged 2 years and over have a BMI based on age and sex of >+1 standard deviation, and obesity has BMI of >+2 standard deviations.

Based on the results of a meta-analysis of 21 primary studies in this study, it was shown that someone with low physical activity has a risk of being overweight or obese 1.35 times compared to high physical activity (aOR=1.35; 95% CI= 1.09 to 1.68; p<0.001). The results of this study are in line with research by (Keetile et al., 2019) which shows that poor physical activity is significantly associated with overweight or obesity. A person with poor physical activity is 1.46 times more likely to be overweight or obese than someone with good physical activity (aOR= 1.46; 95% CI= 1.03 to 2.07).

Research by (Fikre et al., 2022) also showed similar results, namely the percentage of low physical activity was higher in someone who was overweight or obese (18.5%) compared to high physical activity (3.7%). The results of this study also show that reduced physical activity is a significant risk factor for overweight or obesity.

### The effect of alcohol on Overweight or obesity

Alcohol can be a drug of addiction, besides that it can be a cause of about 60 different types of diseases and conditions, and alcohol consumption is one of the factors involved in the development of obesity in adults. One study showed that someone who consumed 1 to 2 drinks of alcohol per week had a higher risk of obesity compared to someone who consumed 3 to 5 drinks per week (Anderson, 2008; IARD Health Review, 2013).

The results of a meta-analysis of 13 primary studies in this study showed that someone with high alcohol had a risk of being overweight or obese 1.47 times com-

pared to low alcohol (aOR=1.47; 95% CI= 1.31 to 1.65; p<0.001). The results of this study are in line with research by (Arfines et al., 2020) which shows that alcohol consumption is significantly associated with overweight or obesity. A person who consumes alcohol is 1.37 times more likely to be overweight or obese than someone who does not consume alcohol (aOR= 1.37; 95% CI= 0.52 to 3.61). The results of this study also show that increased alcohol consumption is a significant risk factor for overweight or obesity.

This meta-analysis shows that physical activity and alcohol have a significant effect on overweight or obesity. Meanwhile, the effect of vegetable and fruit consumption on overweight or obesity is statistically close to significant. Low physical activity has a risk of being overweight or obese 1.35 times compared to high activity, low consumption of vegetables and fruit has a risk of experiencing overweight or obesity 1.40 times compared to high consumption of vegetables and fruit, and high alcohol has a risk of experiencing overweight or obesity 1.47 times that of low alcohol.

**The effect of vegetable and fruit consumption on overweight or obesity**

In general, vegetables and fruit are sources of vitamins, minerals and dietary fiber which are recommended for consumption by adults of 400 to 600 grams per day so as to reduce the risk of overweight or obesity (Kemenkes RI, 2014).

The results of a meta-analysis of 9 primary studies in this study showed that a person with low vegetable and fruit consumption had a risk of being overweight or obese 1.40 times compared to someone with a high consumption of vegetables and fruit (aOR=1.40; 95%CI= 0.94 to 2.08; p<0.001).

The results of this study are in line with research by (Mogre et al., 2015) which shows that low vegetable and fruit consumption is significantly associated with overweight or obesity. Someone with a low consumption of vegetables and fruit has a 2.60 times chance of being overweight or obese compared to someone with a high consumption of vegetables and fruit (aOR= 2.60; 95% CI= 1.20 to 5.63). The results of this study also show that reduced consumption of vegetables and fruit is a significant risk factor for overweight or obesity.

This study has several limitations, including language bias because this research only uses primary studies published in English. In this study, there were also limitations in searching for primary studies because the researcher only searched 3 online databases, namely Google Scholar, PubMed, and Proquest

## AUTHOR CONTRIBUTION

Dena Tri Solehaini as the main researcher who selects topics, conducts searches for research data collection, and conducts research data analysis. Bhisma Murti and Burhannudin Ichsan conducted a review of research documents.

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## CONFLICT OF INTEREST

There is no conflict of interest in this study.

## REFERENCES

Anderson P (2008). The Impact of Alcohol on Health. Beer: 120–154. doi: 10.1002/9780470774540.ch6.

Anstey J, Cherbuin N, Budge M, Young, J. (2011). Body mass index in midlife

and late-life as a risk factor for dementia: a meta-analysis of prospective studies. 10: 426–437. doi: 10.1111/j.1-467-789X.2010.00825.x.

Arfines P, Luglio F, Kusumawardani N. (2020). Prevalence and Lifestyle Risk Factors of Overweight and Obesity Among Indonesian Adolescents: An Analysis of Global School-Based Health Survey 2007 and 2015. Atlantis Press. doi: 10.2991/ahsr.k.20-0215.098.

Aryeetey R, Lartey A, Marquis S, Nti H, Colecraft E, Brown P. (2017). Prevalence and predictors of overweight and obesity among school-aged children in urban Ghana. BMC Obes. 4(38): 1–8. doi: 10.1186/s40608-017-0174-0.

Baniissa W, Radwan H, Rossiter R, Fakhry R, Hasan S, Macridis S, et al. (2020). Prevalence and determinants of overweight/obesity among school aged adolescents in the United Arab Emirates : a cross-sectional study of private and public schools. BMJ open. doi: 10.1136/bmjopen-2020-038667.

Bejarano G, Brayton P, Ranjit N, Hoelscher M, Brown D. (2022). Weight status and meeting the physical activity, sleep, and screen - time guidelines among Texas children: results from a population based, cross sectional analysis. BMC Paediatr Open. doi: 10.11-86/s12887-022-03488-8.

Besa C, Mulenga D, Babaniyi O. (2013). Overweight and Obesity in Kaoma and Kasama Rural Districts of Zambia: Prevalence and Correlates in 2008-2009 Population Based Surveys. J. Hypertens. 02(01): 2–7. doi: 10.4172-/2167-1095.1000110.

Bogale A, Zewale A. (2019). Determinant factors of overweight / obesity among federal ministry civil servants in Addis Ababa, Ethiopia:a call for sector - wise occupational health program. BMC Res Notes. 12 (449): 1–6. doi: 10.1186-/s13104-019-4489-4.

CDC (2022). Alcohol Use and Your Health. Centers for Disease Control and Prevention.

Dagne S, Gelaw A, Abebe Z, Wassie M. (2019). Factors associated with overweight and obesity among adults in northeast Ethiopia: a cross - sectional study. Dovepress. 12: 391–399.

Dai H, Alsalhe A, Chalghaf N, Ricc M, Bragazzi L, Wu J. (2020). The global burden of disease attributable to high body mass index in 195 countries and territories, 1990 – 2017: An analysis of the Global Burden of Disease Study. PLoS Med. doi: 10.1371/journal.pmed.1003198

Darebo T, Mesfin A, Gebremedhin S. (2019). Prevalence and factors associated with overweight and obesity among adults in Hawassa city, southern Ethiopia: a community based cross-sectional study. BMC Obes. 6(8): 1–10. doi: 10.1186/s40608-019-0227-7.

Fikre A, Shehmolo M, Id B, Oumer B. (2022). Magnitude and risks of overweight/obesity among adults in Welkite town, Southern Ethiopia: A community based cross-sectional study. PLoS One. doi:10.1371/journal.pone.-0275014.

Hruby A, Hu FB (2016). The Epidemiology of Obesity: A Big Picture. Pharmacoeconomics. 33(7): 673–689. doi: 10.1-007/s40273-014-0243-x.

IARD. (2013). Drinking and Obesity. International Alliance for Responsible Drinking.

JBI. (2017). Checklist for analytical cross-sectional studies. Joanna Briggs Institute

Kabwama N, Kirunda B, Mutungi G, Wesonga R, Bahendeka K, Guwatudde D. (2018). Prevalence and correlates of abdominal obesity among adults in Uganda: findings from a national cross-sectional, population based survey 2014. BMC obesity. 5(40): 1–9. doi: 10.1186/s40608-018-0217-1.

Keetile M, Navaneetham K, Letamo G, Bainame K, Rakgoasi D, Gabaitiri L, Masupe T, et al. (2019). Socioeconomic and beha-vioural determinants of over-weight/obesity among adults in Bots-wana: a cross-sectional study. BMJ Open. doi: 10.1136/bmjopen-2019-029570

Kemenkes RI. (2014). Pedoman gizi seimbang. Kementerian Kesehatan Republik Indonesia

Kemenkes RI. (2015). Pedoman Umum Pengendalian Obesitas. Kementerian Kesehatan Republik Indonesia

Ladhani M, Craig C, Irving M, Clayton A, Wong G. (2017). Obesity and the risk of cardiovascular and all-cause mortality in chronic kidney disease: A systematic review and meta-analysis. Nephrol Dial Transplant. 32(3): 439–449. doi: 10.1093/ndt/gfw075.

Mawaw P, Yav T, Mukuku O, Kakisingi C, Kakoma B, Luboya N. (2017). A cross-sectional study on obesity and related risk factors among women of the central market of Lusonga in Lubumbashi, Democratic Republic of Congo. AFENET. doi: 10.11604/pamj.2017.28.157.13762.

Mayulu N. (2013). Hubungan Antara Aktivitas Fisik Dengan Obesitas Pada Wanita Usia Subur Peserta Jam-kesmas di Puskesmas Wawonasa Kecamatan Singkil Manado. eBiomedik. 1: 1040–1046. doi: 10.35790/ebm.v1i2.-3255

Mekonnen T, Animaw W, Seyum Y. (2018). Overweight / obesity among adults in North-Western Ethiopia: a community-based cross sectional study. BMC. 78(18): 1–6. doi: 10.1186/¬s13690-018-0262-8.

Mekonnen T, Tariku A, Abebe M (2018). Overweight/Obesity among school aged children in Bahir Dar City: cross sectional study. BMC. 44(17): 1–8. doi: 10.1186/s13052-018-0452-6.

Menon S, Philipneri A, Ratnasingham S, Manson H (2019). The integrated role of multiple healthy weight behaviours on overweight and obesity among adolescents: a cross- sectional study. BMC Pub Health. 19(1157): 1–12. doi: 10.1186/s12889-019-7007-7.

Mogre V, Nyaba R, Aleyira S, & Sam B. (2015). Demographic, dietary and physical activity predictors of general and abdominal obesity among university students: a cross-sectional study. SpringerPlus, doi: 10.1186-/s40064-015-0999-2

Rudatsikira E, Muula S, Mulenga D, Siziya S. (2012). Prevalence and correlates of obesity among Lusaka residents, Zambia: a population-based survey. BMC. 5(14): 1–6.

Sheikh P, Smith G, & Hasan R. (2022). Determinants of Double Burden of Malnutrition Among School Children and Adolescents in Urban Dhaka: A Multi-Level Analyses. Front Public Health. doi: 10.3389/fpubh.2022.926571

Simo P, Agbor N, Temgoua Z, Cedric L, Fozeu F, Bonghaseh T, et al. (2021). Prevalence and factors associated with overweight and obesity in selected health areas in a rural health district in Cameroon: a cross-sectional analysis. BMC Public Health. 21(475): 1–12. doi: 10.1186/s12889-021-10403-w.

Sudikno, Herdayati M, Besral (2010). Hubungan Aktifitas Fisik Dengan Kejadian Obesitas Pada Orang Dewasa di Indonesia. Analisis Data Riskesdas 2007.

Tateyama Y, Techasrivichien T, Musumari M, Suguimoto P, Zulu R, Macwan M, et al. (2018). Obesity matters but is not perceived: A cross- sectional study on cardiovascular disease risk factors among a population-based probability sample in rural Zambia. PLoS ONE. doi: 10.1371/journal.pone.0208176.

Tekalegn Y, Solomon D, Sahiledengle B, Assefa T, Bekele K, Zenbaba D, et al. (2022). Prevalence of central obesity and its associated risk factors among adults in Southeast Ethiopia: A community-based cross-sectional study. PLoS ONE. doi: 10.1371/journal.pone-.0265107.

HHS. (2018). Physical Activity Guidelines for Americans 2nd edition. Department of Health and Human Services.

WHO. (2021). Obesity and Overweight. World Health Organization.

WHO. (2022). The Global Health Observatory: Nutri-tion-Body Mass Index. World Health Organization.

WOF. (2022a). Child-hood Obesity. World Obesity Federation.

WOF. (2022). World Obesity Atlas 2022. March. World Obesity Federation.

Zubery D, Kimiywe J, Martin D. (2021). Prevalence of Overweight and Obesity, and Its Associated Factors Among Health-care Workers, Teachers, and Bankers in Arusha City, Tanzania. Dovepress. Diabetes Metab Syndr Obes. doi:10.2147/DMSO.S283595.