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# Meta Analysis Study: Nutritional Factors in the Incidence of Type 2 Diabetes Mellitus (DM) with Obesity

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**ABSTRACT:** Improvement prevalence obesity and type 2 diabetes mellitus (DM) become challenge significant global health, especially affected by changes style life like pattern Eat No health and lack of activity Physical. This study aims to analyze the influence of nutritional factors on the incidence of type 2 diabetes mellitus (DM) with obesity through a meta-analysis approach. The method used was a systematic review of articles published in 2019–2024 obtained from the PubMed, DOAJ, PLoS One, and Google Scholar databases, with a focus on dietary factors and physical activity.
The analysis of 21 observational articles with cohort and case-control study designs eligible for meta-analysis showed that unhealthy diets and low physical activity significantly contribute to the increased risk of type 2 diabetes in obese individuals. This meta-analysis emphasizes the importance of nutritional factors as modifiable determinants in the prevention and management of type 2 diabetes in obesity. These findings provide a strong scientific basis for the development of nutrition- and lifestyle-based public health policies and interventions.

**KEYWORDS:** Meta-analysis, type 2 diabetes mellitus, obesity, nutritional factors, diet, physical activity.

## INTRODUCTION

Rapidly development global urbanization and modernization have impact term length on aspect style life like behavior No healthy , including pattern eating and activities physical, plus with trend genetic, encouraging occurrence improvement incident obesity and type 2 diabetes (DM type 2) worldwide. Sufferers obesity experience insulin resistance, which is characterized with disturbance insulin action in the liver and reduced taking glucose in fat and muscle. Although change style life and treatment recommended For prevention, things the Not yet succeed pressing improvement incident obesity and type 2 diabetes. [1]

Obesity is the result of a complex interaction between genetic, epigenetic, lifestyle, socioeconomic, cultural, and other environmental influences. Currently, obesity affects approximately 22% of people worldwide, constituting a global epidemic. One of the main drivers of the obesity epidemic is the globalization of food systems, which has resulted in increasingly processed, affordable, and highly palatable foods, and has also encouraged the overconsumption of foods and beverages high in energy and low in nutrients. [2]

Obesity is a driving factor that has a strong influence on the increasing epidemiology of type 2 diabetes, almost equally through the adaptation of unhealthy diets and lack of physical activity. Furthermore, an increasing number of elderly people, children, and adolescents are also being diagnosed with type 2 diabetes due to the prevalence of childhood obesity. Compared with type 1 diabetes, adolescents with type 2 diabetes have a greater chance of developing cardiometabolic complications due to an increased risk of hypertension, hyperlipidemia, and central obesity .

Hyperglycemia, a characteristic of type 2 diabetes mellitus (DM), has recently become a global health threat. Chronic hyperglycemia is the primary sign of type 2 DM, caused by a combination of insulin resistance and inadequate compensatory insulin secretion, and typically occurs in obese individuals.

Type 2 diabetes mellitus and its complications are a major public health problem worldwide, affecting nearly all populations in both developed and developing countries, with high morbidity and mortality rates. High prevalence has been observed in developing countries and in modernizing populations. Various risk factors for type 2 diabetes, such as genetics, lifestyle, and other factors, contribute to an increased risk of type 2 diabetes. [5]

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Nutritional factors are elements that influence a person's nutritional status. Nutritional status is the condition of the body that occurs after consuming food as a result of nutrient metabolism that is in accordance with the body's needs to carry out its functions. [6] Various nutritional factors influence the incidence of obesity and type 2 diabetes, such as an unhealthy lifestyle indicated by and/or lack of physical activity, causing overweight and obesity, which are risk factors for type 2 diabetes. Dietary restrictions are determined to reduce the incidence of type 2 diabetes and to improve metabolic control. Although there is a role for genetic and environmental risk factors for the incidence of type 2 diabetes, modifiable lifestyle-related factors play a large role at the individual level. [7] The purpose of this study was to analyze the influence of various nutritional factors on the incidence of type 2 diabetes with obesity.

## METHOD

Types of research is Meta- analysis research. Meta-analysis is a statistical approach in synthesizing quantitative research results. The research was conducted from August to December 2024. The data sources for this research were obtained from internet searches through the MEDLINE (PubMed), DOAJ (directory of open access journals), PLoS One, and Google Scholar databases published from 2019 to 2024. In this study, contact with researchers in related fields and manual searches were not carried out. Keywords were arranged according to the problem formulation based on the S-PICO and MeSH (Medical Subject Headings) guidelines. The keywords used were is (Obesity OR Obesity) AND (Diabetes Mellitus) Type 2 OR Type 2 Diabetes Mellitus) AND (activity physical OR physical activity) AND (pattern eating OR dietary habit).

The research results included in the meta-analysis (sample) were then selected based on clear inclusion and exclusion criteria. This study used only published research, thus exposing the potential for publication bias, which is the presence of valid, unpublished research that was not included in the meta-analysis and may have influenced the results. The systematic review process used PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis), a set of evidence-based minimum items intended to assist in reporting various systematic reviews and meta-analyses. It is used to demonstrate the quality of the review, assess strengths and weaknesses, and replicate the methodology. Evaluation to ensure that the obtained research met the inclusion and exclusion criteria was carried out in stages, including: (1) titles of identified studies, (2) abstracts of relevant studies, and (3) available full texts. After excluding studies that did not meet the inclusion criteria, the data were standardized and arranged based on certain criteria such as year of publication, location, design, sample size, and results of the study. [8]
Combining various research findings is the most crucial and decisive part of meta-analysis. Studies with different sample sizes and quality cannot be treated equally. Higher-quality studies receive greater weight. Data analysis in this study used a random effects model. [8] This study has received ethical approval from the Health Research Ethics Committee of the Faculty of Medicine, University of Lampung, under the number 95/UN26.18/PP.05.02.00/2025.

## RESULTS AND DISCUSSION

The literature search process was carried out systematically through the MEDLINE (PubMed), DOAJ (directory of open access journals), One, and Google Scholar databases, using a combination of keywords arranged based on the S-PICO framework and MeSH Terms, including: PloS (Obesity OR Obesity) AND (Type 2 Diabetes Mellitus OR Type 2 Diabetes Mellitus) AND (diet OR diet OR physical activity OR physical activity). From the results search the beginning that produces thousands journal , a selection process is carried out as following.

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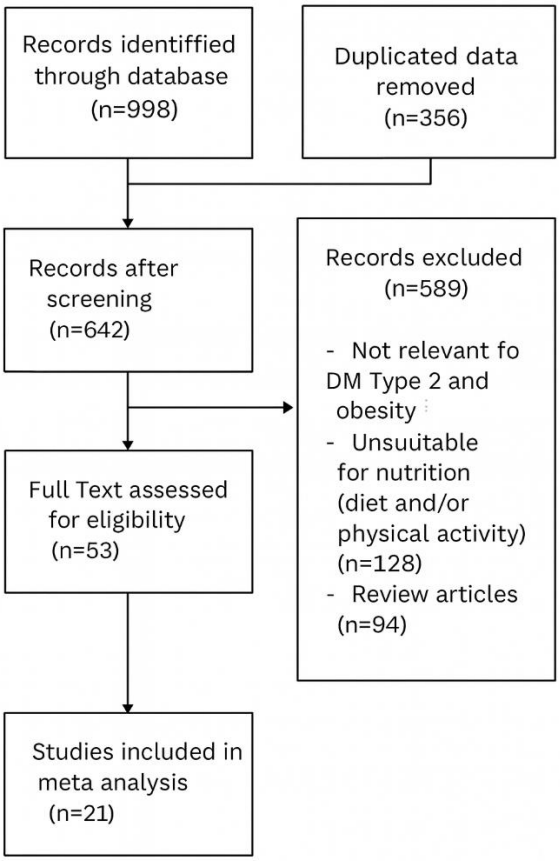


**Figure 1. PRISMA Flowchart**

Search process beginning get results of 998 articles, then perform the deletion process article duplicated, 642 articles were found then, 589 articles issued Because No in accordance with research, articles complete and fulfilling condition totaling 21 next done search full text article included in meta- analysis. The results of the meta- analysis served in the shape of the forest plot shows information from each of the studies studied about results overall and the shape of the funnel plot that depicts possibility the occurrence of publication bias with display relation between magnitude effect study and sample size. [9]

Articles that have been identified and obtained 21 articles observational with design cohort and case control studies that meet the requirements condition as meta- analysis sources factor nutrition in the incidence of type 2 DM with Obesity. There are 11 articles on nutritional factors (dietary patterns), 5 articles on nutritional factors (physical activity), and 5 articles on combined nutritional factors (dietary patterns and physical activity) on the incidence of type 2 diabetes with obesity.

The meta-analysis of 11 articles was conducted with a total sample of more than 713,194 primary research participants in each article conducted in different locations (USA, France, Iran, Japan, China, Egypt, Thailand, etc.). The population in the articles were adults with a BMI > 25. The interventions studied in the articles were the relationship between dietary patterns and the incidence of type 2 diabetes mellitus. The focus of the interventions included consumption of processed foods, fiber, low/high quality diets, and traditional dietary styles (such as the Mediterranean). In general, consumption of unhealthy foods (processed foods, artificial sweeteners, low diet quality) was associated with an increased risk of type 2 diabetes, while a healthy diet reduced the risk. The fundamental similarity of the studies above is that there is a significant influence between dietary patterns on the incidence of type 2 diabetes. The results of the meta-analysis of Nutritional Factors (Diet Patterns) in Type 2 Diabetes and Obesity, based on the forest plot in Figure 2 from 11 studies, showed a Combined Odds Ratio (OR) of 0.02 with a 95% Confidence Interval (IC) of 0.00–0.07. This OR value, which is far below 1, indicates that the group with dietary intervention has a chance of developing Type 2 Diabetes that is approximately 98% lower than the control group (OR ~0.02). A Confidence Interval that does not exceed the value of 1

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indicates statistical significance. This is reinforced by the overall effect test which gives a Z value of 5.72 with p <0.00001, so that statistically there is a significant difference between the dietary intervention and control groups in terms of the risk of Type 2 Diabetes. [13,14,15]

A healthy diet or nutritional intervention consisting of various interventions (processed food intake, artificial sweetener consumption, high fiber intake, low diet quality, Mediterranean diet, high fat and salt intake) related to obesity tends to reduce the risk of developing Type 2 DM in obese populations. [16,17,18] The funnel plot in Figure 3 shows a non-symmetrical distribution of studies. Most studies tend to be clustered on the left side (the area with an OR <1 indicating a protective effect of the diet) and relatively few studies on the right side showing a reduced risk (OR below 1), and no studies with a clear effect favoring the control side (OR >1). This asymmetry indicates the possibility of publication bias. A non-symmetrical funnel plot, with most study points clustered on the left side (OR <1, protective effect) and very few on the right side, indicates a gap in data on the side showing no effect or a detrimental effect. This imbalance means that small studies with negative or non-significant results may not be published, resulting in only studies with positive results being published. This phenomenon is in accordance with the concept of publication bias, namely the tendency for only studies with significant results to be reported and published. [9]

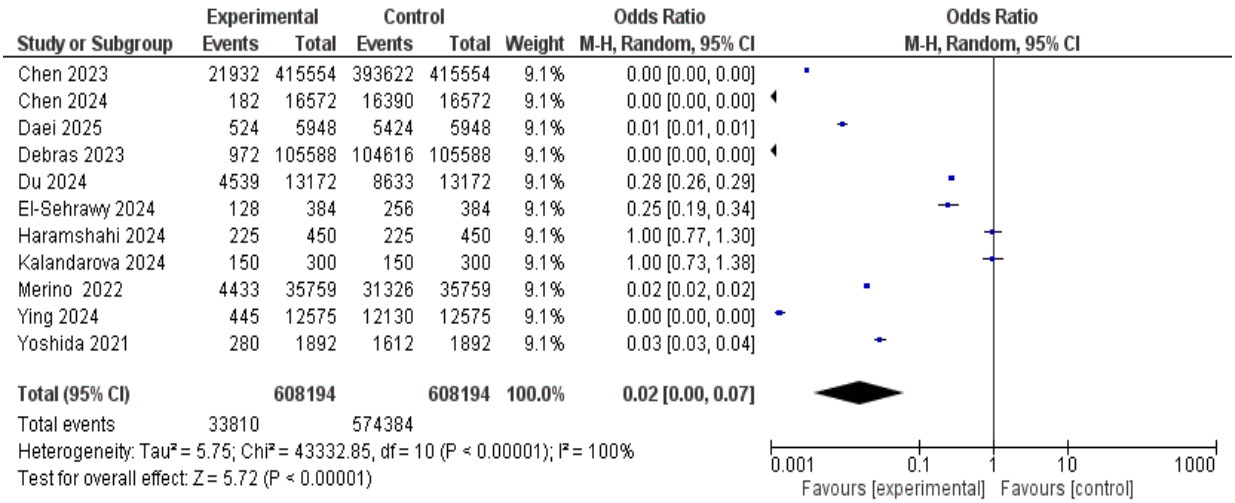


**Figure 2. Forest Plot of Nutritional Factors (Diet Patterns) in Type 2 DM with Obesity**

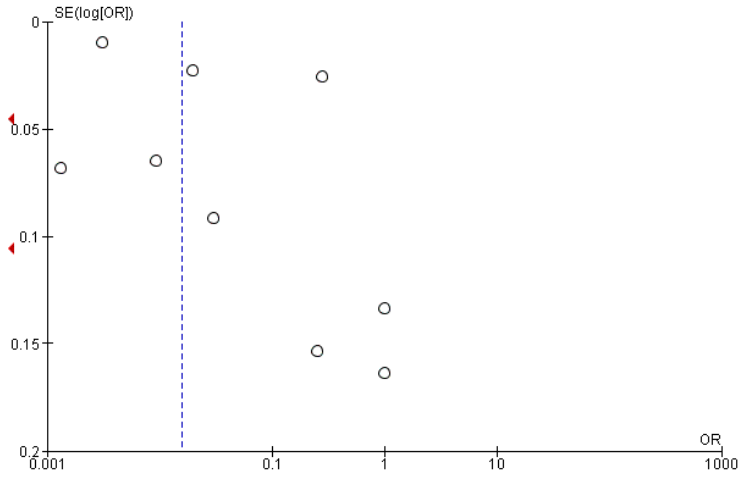


**Figure 3. Funnel Plot of Nutritional Factors (Diet Patterns) in Type 2 DM with Obesity**

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A meta-analysis of 11 articles on dietary patterns comprising various interventions (processed food intake, artificial sweetener consumption, high fiber intake, low diet quality, Mediterranean diet, high fat and salt intake) showed that dietary patterns have a significant association with the risk of type 2 diabetes in obese populations. [20,21,22,23]

The meta-analysis involved five articles with a total sample of 137,534 participants. The primary studies were conducted in different locations (China, Pakistan, the UK, and Sweden). The population in the articles was adults with a BMI > 25. The interventions studied in the articles were low, moderate, and high physical activity on the incidence of type 2 diabetes mellitus with obesity. The interventions involved various forms of physical activity: daily intensity, work, and Physical Activity Energy Expenditure (PAEE). All articles mentioned the outcome, namely the incidence of type 2 diabetes mellitus. Studies consistently show that moderate to high physical activity plays a protective role in reducing the incidence of type 2 diabetes mellitus, while low activity or obesity increases the risk. The fundamental similarity of these studies is that there is a significant influence between physical activity on the incidence of type 2 diabetes mellitus and obesity. [24,25,26]

Meta-analysis Results of Nutritional Factors (Physical Activity) on Type 2 DM with Obesity Figure 4. Forest Plot shows the odds ratio (OR) of the Combination of five studies is around 0.01 with a 95% Confidence Interval (IC) of 0.00–0.06. An OR value <1 indicates that the group with physical activity intervention has a lower chance of experiencing Type 2 DM than the control group. The direction of the effect is consistent towards a decrease in risk in the intervention group (OR below 1 for most studies), and in terms of strength the effect of the Combination results is statistically significant because the CI does not cross 1. The overall effect test produces Z = 4.78 with p <0.00001, indicating that there is a statistically significant difference between the intervention and control groups in the incidence of Type 2 DM. The funnel plot is symmetrical like an inverted cone if there is no publication bias. In Figure 5, the distribution of studies appears less symmetrical. This asymmetric pattern indicates the possibility of a small-study effect or publication bias. [9]

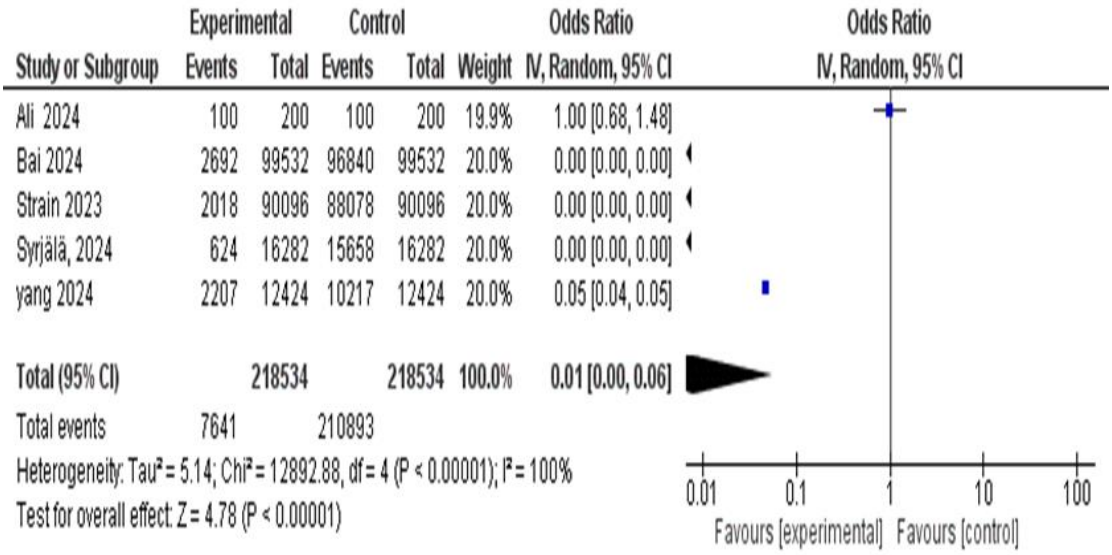


**Figure 4. Forest Plot of Nutritional Factors (Physical Activity) in Type 2 DM with Obesity**

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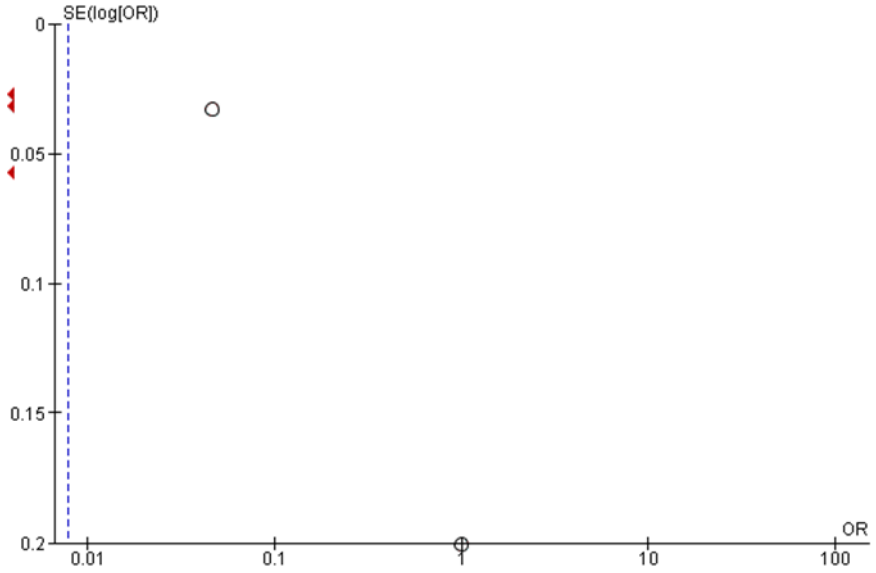


**Figure 5. Funnel Plot of Nutritional Factors (Physical Activity) in Type 2 DM with Obesity**

Physical activity is a crucial component in energy regulation and glucose metabolism. Lack of physical activity (a sedentary lifestyle) directly contributes to weight gain due to low energy expenditure. When the body rarely moves or exercises, unused calories from food are stored as fat. A sedentary lifestyle is associated with a higher risk of obesity. Conversely, people who are active have better weight control. Individuals who engage in moderate levels of physical activity have a 28% lower risk of obesity than those who are inactive, and those who engage in vigorous levels of physical activity have a 34% lower risk. Physical activity helps prevent body fat gain by increasing energy expenditure and can increase metabolic rate. Furthermore, regular exercise improves body composition by increasing muscle mass; this is important because skeletal muscle is a tissue that burns large amounts of calories and is the primary target of insulin for blood glucose absorption. [10,27,28]

The study conducted a meta-analysis of 5 articles with a total sample of 363,795 adult participants from various ethnic backgrounds and regions (Denmark, the Netherlands, the UK, China, and the USA). The population in the articles were adults with a BMI > 25 who evaluated the combination of diet and physical activity on the risk of type 2 diabetes. These articles measured lifestyle scores or a combination of habits such as a healthy diet, physical activity, and body weight. The results of each article showed that adherence to a healthy lifestyle significantly reduced the risk of type 2 diabetes . [29,30,31]

Meta-analysis results of Combined Nutritional Factors (Diet and Physical Activity) on Type 2 DM with Obesity based on Figure 6. Forest Plot shows the results of the Combination of five intervention studies The combination of diet and physical activity showed a reduced risk of Type 2 DM in the obese population compared to the control group. The resulting Combination Odds Ratio (OR) value is 0.01 with a 95% Confidence Interval (CI) of 0.00–0.14 which is far below 1 indicating that statistically, the chance of Type 2 DM in the intervention group is only about 1% of the control group. Because the 95% CI does not cross the number 1, this Combination effect is statistically significant. The Z-test for the overall effect also supports this, with $Z = 3.35$ ($p = 0.0008$), which means there is a significant difference between the intervention and control groups in terms of the incidence of Type 2 DM. The combination of healthy diet and physical activity interventions is associated with a significant reduction in the incidence of Type 2 DM in obese people. The direction of the effect is consistently protective (OR < 1), indicating that all studies tend to report a benefit of the intervention in preventing DM, although the magnitude varies across studies. In the funnel plot of this meta-analysis, the distribution of studies appears less symmetrical. Almost all studies are on the left side of the effect line (OR = 1), indicating that all studies report a protective effect (OR < 1) against Type 2 DM. [29,30,31]

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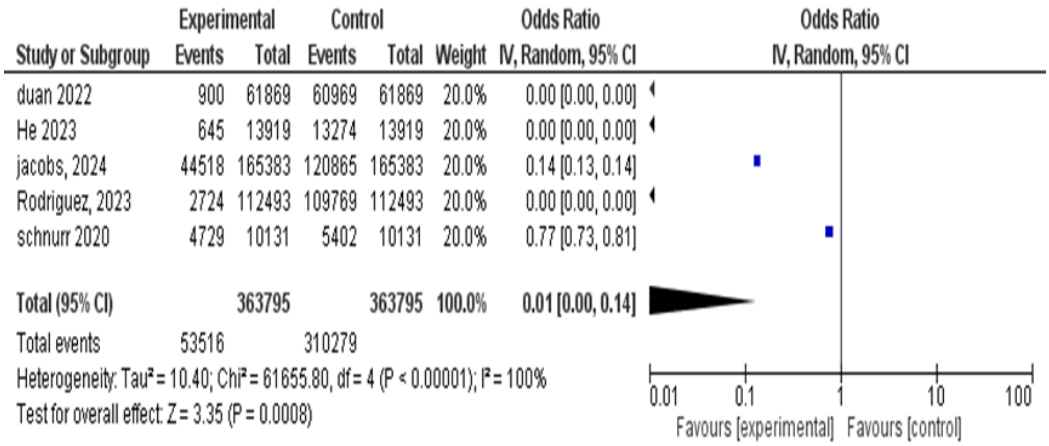


**Figure 6. Forest Plot of Combined Nutritional Factors (Diet Pattern and Physical Activity) in Type 2 DM with Obesity**

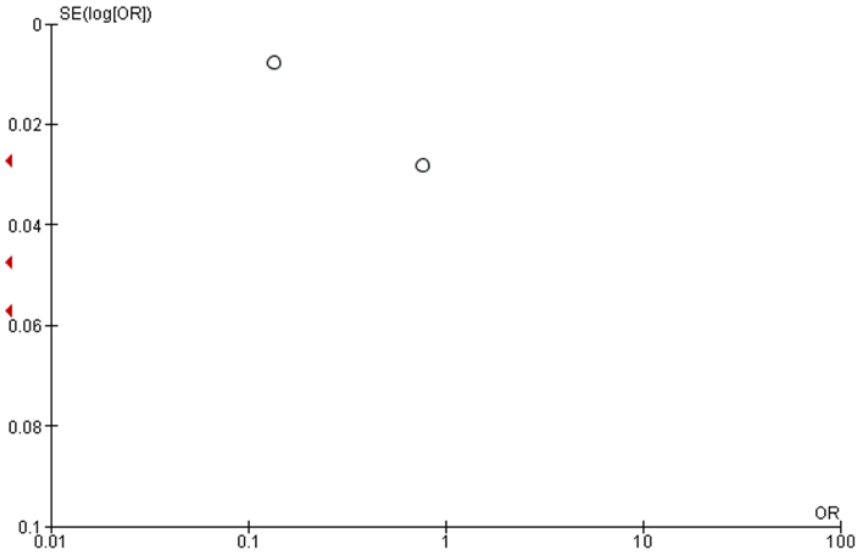


**Figure 7. Funnel Plot of Combined Nutritional Factors (Diet and Physical Activity) in Type 2 DM with Obesity**

Combining a healthy diet with regular exercise provides a synergistic effect in preventing type 2 diabetes in obese individuals. Intensive lifestyle interventions (diet + activity) consistently report greater reductions in the incidence of type 2 diabetes than either intervention alone. [11] Lifestyle interventions that combine improved diet and increased physical activity have been shown to be highly effective in preventing and managing type 2 diabetes. This comprehensive approach results in significant weight loss, improved glycemic control (reduced HbA1c), increased insulin sensitivity, and may even prevent the onset of type 2 diabetes in high-risk individuals. The effects of diet and exercise are mutually reinforcing: diet reduces body fat and glucose intake, while exercise improves glucose utilization and insulin efficiency – the combination of the two provides superior clinical outcomes to either intervention alone. [12,32,33]

## CONCLUSION

Based on the analysis results, the meta-analysis results show that nutritional factors play an important role in the incidence of Type 2 DM in obese individuals.

Diet: An unhealthy diet (high in fat, salt, sugar, processed foods, artificial sweeteners) increases the risk of Type 2 DM, while a healthy diet (rich in fiber, fruits, vegetables, whole foods) is protective.

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Physical activity: Physical activity has been shown to reduce the risk of Type 2 DM by increasing insulin sensitivity, reducing weight, and preventing insulin resistance.
Combination: Integration of healthy eating patterns and physical activity has the most significant impact on preventing Type 2 DM in obese populations.

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