

# Effect of Weight Control Intervention on Body Mass Index among Adolescents with Overweight: A Systematic Review and Meta-Analysis

## Abstract

**Background:** Due to the dramatic rise in overweight and obesity, adolescent weight management interventions are required. Therefore, this study aimed to study the components and the effect size of weight control programs for adolescents with overweight and obese. **Materials and Methods:** Following the PRISMA 2020 guidelines, we systematically searched electronic databases (PubMed, Google Scholar, ThaiJo, ThaiLis, and Embase) through December 2021 published in English and Thai, samples aged 15–22 years, and presenting the mean, SD a sample size of both experimental and control groups. However, we excluded articles other than full-text articles. In addition, a risk of bias assessment was performed according to the Cochrane Collaboration's quality assessment tool. Finally, this meta-analysis included six studies that met the criteria. The meta-analysis used a fixed-effects model with a forest plot to compute effect sizes and Cochran's Q and I<sup>2</sup> statistics as measures of heterogeneity. **Results:** We found six primary studies which included 721 overweight adolescents. The analysis of the effectiveness of weight control programs for overweight adolescents revealed that 360 adolescents with overweight and obese (49.93%) who underwent the weight control programs changed body weight and body mass index values with the effect size of -0.80 (-1.03, -0.56) and I<sup>2</sup> was 56.00%. **Conclusions:** The results indicate further studies should focus on constructing programs that consider adolescents' changes in technology and lifestyles. Additionally, social and mobile tools should motivate and educate adolescents about body weight control to help them adapt to a healthy lifestyle and maintain weight control over time.

**Keywords:** Adolescent, body weight, overweight

## Introduction

Being overweight among adolescents is a global problem growing alarmingly. Adolescents with overweight are causing health, mental health, social, and lifestyle problems more than children and adolescents with average weight.<sup>[1,2]</sup> Reports in the United States between 1980 and 2018 showed an increase of 10.00–21.00% in overweight and obesity, especially among adolescents aged 12–19 years, which was significantly higher.<sup>[3]</sup> Adolescents aged 15–19 years have an increased prevalence of overweight (girls: 18.00% and boys: 19.00%).<sup>[4]</sup> However, being overweight has a long-term impact on physical health. It continues working age because it is a risk factor for almost all chronic diseases and Noncommunicable Diseases (NCDs) like diabetes, high blood pressure, heart disease, cancer, and bone and joint diseases.<sup>[5,6]</sup> In addition, during adolescence, which is the

transitional stage to adulthood, adolescents with overweight face social image, have friends, and date friends of the opposite sex, causing social harassment, gossip, mental health problems, and socialization.<sup>[7,8]</sup> These adolescents find ways to control weight, such as weight loss and diet pills. Therefore, we should not ignore the problem of being overweight in adolescents because it may affect the development of the potential of a person of all ages.

In Thailand, overweight and obesity problems have increased by more than 48.20% in the past five years, or more than 20 million people.<sup>[9]</sup> This makes the health trend of Thai people move closer to a chronic disease society. More problematic and worrying is that over 10 million Thai adolescents are overweight. The prevalence of overweight is 42.40%.<sup>[9]</sup> It will become a problem for obese adults in the future if

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overweight cannot be changed in this population. In the end, Thai society will face working age with obesity who are at risk of chronic diseases. Therefore, this issue must be taken seriously.

Previous research from many countries, namely, the United States, South Korea, Brazil, and China, used a variety of strategies to reduce overweight and obesity in adolescents, such as promoting physical activity,<sup>[10,11]</sup> high-energy diet control,<sup>[10,12]</sup> high-energy diet control in children,<sup>[13]</sup> and various weight control programs.<sup>[14,15]</sup> However, the research results were different. Therefore, it is impossible to determine which program is appropriate for weight control in adolescents. Thus, documentary research was conducted through a systematic literature review to search, review, evaluate, and synthesize the study published in the database. This study aimed to systematically analyze the pooled effect size of weight control interventions on body mass index among adolescents with overweight. The results of this study can be used as empirical evidence to develop an appropriate for managing body weight among future adolescence.

## Materials and Methods

The current meta-analysis was based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.<sup>[16]</sup> We started the study in 2021 by searching for studies published in English until December 2021. The search databases were PubMed, Google Scholar, ThaiJo, ThaiLis, and Embase. The proposed databases included published and unpublished documents. Therefore, most health science articles should be able to be searched from PubMed, Google Scholar, or ThaiJo. As for any articles that cannot be searched in the database as mentioned above, including dissertations, we used ThaiLis and Embase for searching. The keywords used in the search included “*program*” AND “*weight control*” AND “*adolescent*,” based on the PICO framework: P (population): “*Adolescent/youth, teenage, young*,” I (intervention): “*program, weight control intervention*,” C (comparison): “*control group*,” O (outcome): “*Body Mass Index: BMI*.” The inclusion criteria of this review were as follows: (1) Published in English and Thai from 2000 to 2021 on adolescent weight control programs, (2) Samples aged 15–22 years, and (3) Having sufficient details for meta-analysis, such as the mean (SD) of the Body Mass Index (BMI) of each sample group and the sample size of both experimental and control groups. However, qualitative research studies, review articles, editorial articles, conference proceedings, and unable to search for full research papers were excluded from this review.

Two researchers searched data from the specific database and keywords for the first data search and selected the research studies according to the inclusion criteria. Based on titles and abstracts, 530 related research studies were found. Other researchers carefully read the abstracts

and research content for the second data search. Then, 35 relevant studies were found. From the third review, 29 studies were excluded due to insufficient data for the meta-analysis. Differences of opinion between the two reviewers were addressed through discussion with a third reviewer. Therefore, six studies that can be used for systematic literature reviews and meta-analyses were selected [Figure 1].

Assessment of bias was performed according to the Cochrane Collaboration’s quality assessment tool for assessing risk of bias.<sup>[17]</sup> The evaluation was divided into low-risk, high-risk, and unclear risks. Based on the bias assessment of the six studies, we found that all studies (100.00%) were identified as random sequence generation (selection bias) and allocation concealment (selection bias). However, it did not clearly explain two studies hiding treatments from subjects, investigators, and evaluators. Therefore, it was an unclear risk. Moreover, it was a low risk for selective reporting (reporting bias) and other biases [Figure 2]. The data extraction form was developed to record data from systematic reviews. The details in the table, including the author’s name, the publication year, the country of publication, the research objectives, the characteristics of the samples in both the experimental group and the control group, the details of weight control programs for overweight adolescents, and findings were presented in Table 1. The general information was synthesized by summarizing the points of interest: the details of weight control programs for overweight adolescents. Then, descriptive statistics analyzed the samples’ available information. Finally, the mean, standard deviation, and sample size of the experimental and control groups used in the meta-analysis were analyzed by RevMan version 5. The heterogeneity test was employed for testing the heterogeneity between each selected research by Cochran’s Q and I<sup>2</sup>. The statistical significance was set at the .05 level. The acceptable criteria

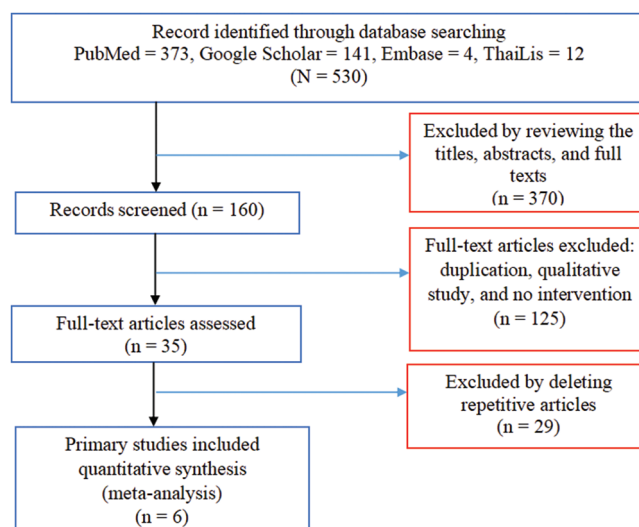
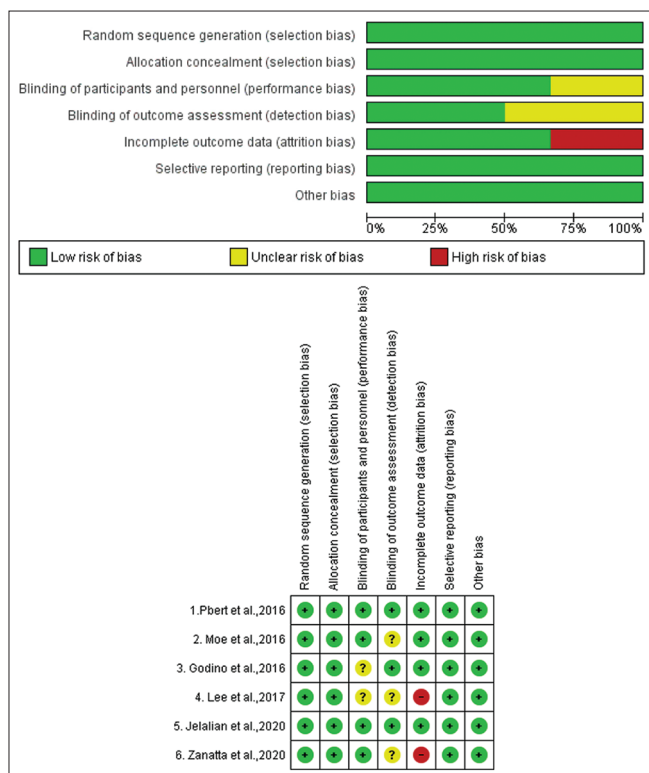


Figure 1: Flowchart of study selection for meta-analysis

**Table 1: Literature reviews of weight control programs for adolescents with overweight and obese**

Author and Country	Programs	Age group (years)	Intervention		Control	
			n	Mean (SD)	n	Mean (SD)
Pbert et al. <sup>[15]</sup> USA	6 months—A school-based program for adolescents with overweight and obese: a randomized controlled trial	15-18	54	30.66 (0.73)	57	31.65 (0.69)
Moe et al. <sup>[14]</sup> USA	24 months—Recruiting and retaining young adults in a weight gain prevention trial: lessons learned from The Choosing Healthy Options in College Environments and Settings (CHOICES) study	18-19	36	25.30 (4.10)	37	26.40 (4.20)
Godino et al. <sup>[13]</sup> USA	24 months—Using social and mobile tools for weight loss in overweight and obese young adults (Project Social Mobile Approaches to Reduce Weight (SMART): a 2-year parallel-group randomized controlled trial	18-22	202	28.90 (2.80)	202	29.00 (2.70)
Lee et al. <sup>[12]</sup> South Korea	10 days—Effects of a 10-day intensive health promotion program combining diet and physical activity on body composition, physical fitness, and blood factors of young adults: a randomized pilot study	19-21	16	21.10 (2.40)	14	21.60 (4.00)
Jelalian et al. <sup>[10]</sup> USA	10 months—JOIN for ME: Testing a scalable weight control intervention for adolescents	16-19	33	35.40 (6.70)	33	33.80 (6.50)
Zanatta et al. <sup>[11]</sup> Brazil	3 months—Effect of an interdisciplinary intervention with motivational approach on exercise capacity in obese adolescents: a randomized controlled clinical trial	15-18	19	34.90 (6.10)	18	34.40 (4.40)



**Figure 2: Risk of bias graph and summary**

for  $I^2$  were as follows: not significant (0.00-24.00%), low heterogeneity (25.00-49.00%), medium heterogeneity (50.00-74.00%), and high heterogeneity (75.00-100.00%).<sup>[18]</sup> Quality appraisal was examined for publication bias by funnel plots using RevMan version 5. Publication bias was determined by the  $p$ -value set at 0.05.

**Ethical considerations**

This review article not needed ethical approval because it does not contain any studies with human participants, so

informed consent was not required. The authors committed to avoiding duplicate publication and plagiarism. The results of the analysis were sincere. In this systematic review and meta-analysis, the collected data were concerned only for scientific purposes, and reporting and publication were respected in intellectual property.

**Results**

**The analysis results of all weight control programs for adolescents with overweight**

The fixed model was employed in the analysis. Due to the outcome measured being body mass index (BMI), which has the same international benchmark and uses the same unit of measurement, a fixed-effects model may be appropriate. As a result, the medium of heterogeneity was found ( $I^2 = 56.00\%$ ;  $p$ -value  $< 0.04$ ). The analysis results of 721 adolescents from six studies revealed that 360 persons were overweight. (49.93%) who underwent weight control programs changed BMI values. The effect size was -0.80 (-1.03, -0.56).  $I^2$  was 56.00% [Figure 3]. In addition, the funnel plot examining publication bias is shown in Figure 4. Subgroup analysis of the ready-to-use weight control programs for adolescents with overweight. The ready-to-use weight control programs for adolescents overweight and obese included (1) the Choosing Healthy Options in College Environments and Settings (CHOICES) study, a one-credit enrollment program designed and delivered by the researchers focusing on weight control (proper food, exercise, stress, and sleep management), followed by participation in social networking sites supporting weight tracking and self-tracking, setting goals, and interacting with health behaviors; (2) the Social Mobile Approaches to Reduce Weight (SMART) intervention, a program focusing on the use of communication technology to adjust exercise

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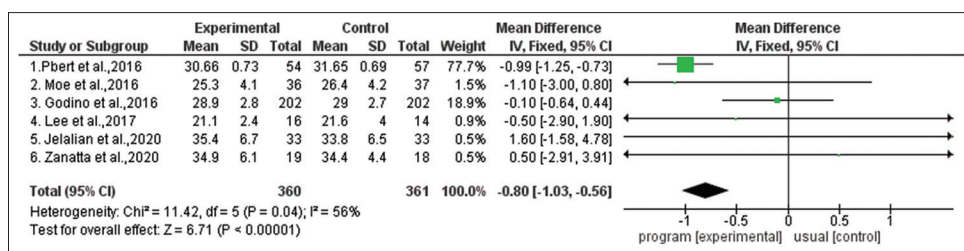


Figure 3: The analysis results of weight control programs for adolescents overweight and obese

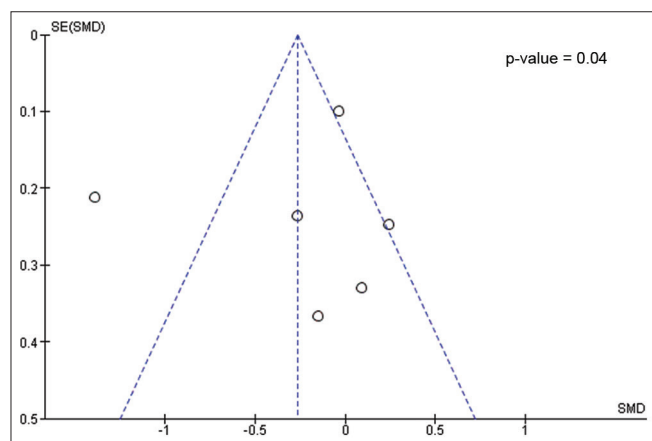


Figure 4: The funnel plot analyses all weight control programs for adolescents with overweight and obese

behavior and diet; and (3) join for me enhance, a 60-minute group exercise program, divided into active exercises by the Young Men’s Christian Association (YMCA) coaches for 20 minutes and 30 minutes of strength training and cardiovascular activities and 10 minutes of warm-up and cool-down. In the analysis, the fixed model was used. It was found that the heterogeneity was at the level of “not important.” The analysis results of 543 adolescents overweight from three full-length studies revealed that 271 persons (49.90%) who underwent weight management programs had a decrease in BMI. The effect size was -0.11 (-0.62, 0.40); I<sup>2</sup> was 0.00% [Figure 5]. In addition, the funnel plot is shown in Figure 6. The weight control programs for adolescents with overweight focusing on diet and exercise were as follows. (1) A diet program by eating five or more servings of fruits and vegetables per day, limiting consumption of sodas and sugary drinks, eating three meals a day, limiting sweets, reducing intake of saturated fat and high-calorie foods, limiting eating out, eating when hungry and stopping when full and determining appropriate proportions, exercising at least 1 hour every day in a week, getting a pedometer and instructions on how to use it, and reducing sedentary behaviors to spend less than 2 hours/day in front of a screen (such as television, video, and computers). (2) The intensive 10-day health promotion program: It is a diet program combined with exercise, doing 6 exercise positions, holding each position for 30 seconds and resting for 15 seconds between moves, doing three rounds of

approximately 40 minutes. The food must be consumed on a timely and scheduled basis, emphasizing eating fruits and vegetables, whole grains, dairy products, eggs, and legumes. Meat, poultry, and seafood are not included. In the analysis using the fixed model, it was found that the heterogeneity was at the level of “not important.” The analysis results of 178 adolescents overweight from three full-length studies revealed that 89 persons (49.90%) who underwent weight management programs had a decrease in BMI. The effect size was -0.98 (-1.24, -0.71). I<sup>2</sup> was 0.00% [Figure 7]. In addition, the funnel plot examining publication bias is shown in Figure 8.

## Discussion

A meta-analysis on the effectiveness of weight control programs for adolescents with overweight indicated that the weight control programs reduced BMI for 10 days to 24 months. The study has found an intervention or program that successfully reduces BMI in overweight adolescents. Several implications can be discussed. One of the most significant implications of reducing BMI in overweight adolescents is the potential for improved health outcomes. Adolescents who are overweight are at increased risk for various health problems, including cardiovascular disease, diabetes, and hypertension. They may reduce their risk of developing these health problems by reducing their BMI. Psychological benefits: Being overweight can harm an adolescent’s self-esteem and body image, leading to shame and social isolation. By reducing BMI, adolescents may experience improved psychological well-being, leading to better academic performance and overall quality of life. Using the existing programs or testing the programs developed from the original ones can help control adolescents’ weight. Social and mobile media use to closely reach adolescents can stimulate real-time weight control. This is consistent with a study by Wisapha *et al.*,<sup>[19]</sup> which found that a mobile weight control application can make overweight adolescents in school more likely to have better dietary habits and physical activity, reducing body weight ( $t = 3.20, p < 0.001$ ). However, overweight adolescents may experience difficulty participating in physical activities, which can limit their social interactions and opportunities for personal growth. By reducing their BMI, adolescents may have improved mobility and increased physical activity and social engagement opportunities.

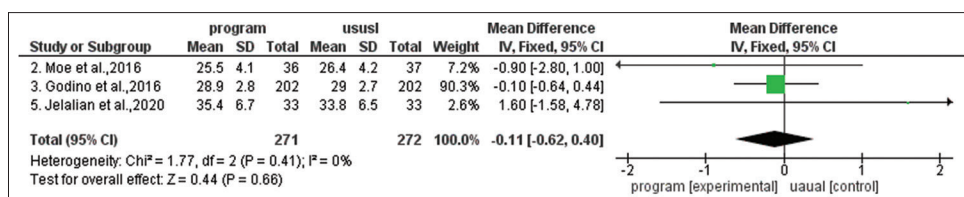


Figure 5: Subgroup analysis of the ready-to-use weight control programs for adolescents overweight and obese

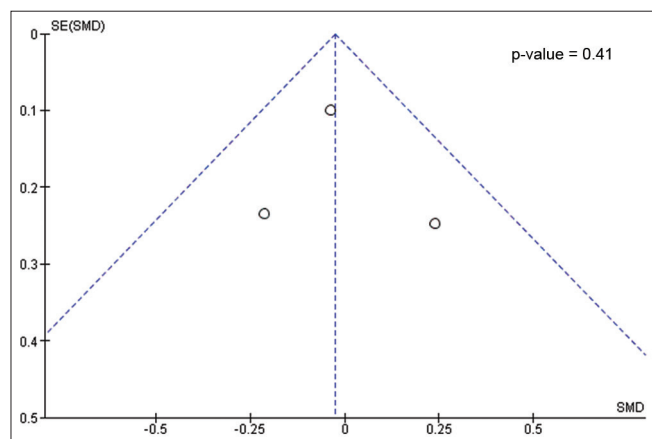


Figure 6: The funnel plot analysis of the ready-to-use weight control programs for adolescents overweight and obese

Programs focusing on exercise and the proper diet to reduce high-energy food intake can change by 50.00% BMI. Studies have found that exercise combined with diet control is an effective way to control weight. Increasing moderate to high-intensity physical activity for 1 hour per day can reduce the risk of obesity by 10.00%. Moreover, continuous exercise for at least 30 minutes 1-2 days a week can produce more energy and burn the accumulated fat in the body. Regular exercise also reduces the fat collected in the abdomen and under the skin. It also improves physical performance. Eating 1-2 scoops of fresh fruit is influential in managing health conditions to prevent obesity.<sup>[20]</sup> A weight management program focusing on changing eating habits decreases BMI by 0.36 kg/m<sup>2</sup>.<sup>[21]</sup> This is consistent with a study on individualized exercise training combined with a fruit and vegetable-rich diet, which can lower insulin levels. A study also found that exercise combined with diet control for six months can reduce triglyceride (TG) and low-density lipoprotein cholesterol (LDL-C) and increase high-density lipoprotein cholesterol (HDL-C) levels after week 12.<sup>[22-24]</sup>

When the body uses energy from aerobic exercise, glycogen, fat, and protein are energy sources. Exercising for 20 minutes or more allows the body to use fat primarily to burn for energy. This has a beneficial effect on cardiometabolic health.<sup>[25]</sup> Moreover, exercise snacks were easy to perform, well tolerated, and associated with a 2.20% loss of body fat mass when both groups were analyzed together ( $p = 0.015$ ) after three months. Likewise, continuous and intermittent aerobic physical

training may improve the hormonal, metabolic profile, and body composition.<sup>[26]</sup> It was found that the percentage of fat and fat mass was reduced. Eventually, continuous fat burning can cause a change in body weight and a decrease in BMI. The long-term implications of reducing BMI in overweight adolescents are also essential to consider. Adolescents who successfully decline their BMI may be more likely to maintain a healthy weight into adulthood, which can significantly impact their long-term health outcomes.

The limitation of this study is that the studies included in the meta-analysis may have been done in specific settings or populations, which may limit the generalizability of the findings to other people. These variations may have influenced the findings and made it difficult to draw definitive conclusions. This heterogeneity may have affected the results and made it difficult to generalize the findings to all overweight adolescents. Some studies may have only measured short-term outcomes, such as changes in BMI or body composition, without measuring long-term effects, such as the impact of weight loss on health outcomes.

Future studies should therefore focus on constructing programs that consider adolescents' changes in technology and lifestyles to educate adolescents about body weight control to help them adapt to a healthy lifestyle and maintain weight control over time. It can be summarized into three crucial implications as follows. The practice can inform healthcare providers on effective ways to prevent and manage overweight in adolescents, such as promoting physical activity and healthy eating habits, and the results can help educators and administrators develop effective adolescent health education programs. The findings can also be used to develop individualized weight management plans for overweight adolescents. About the policy, the research can inform public health policies to prevent and reduce the prevalence of overweight among adolescents. The results can also inform policies around school food and physical education programs to promote healthy behaviors among students and also guide the development of policies around food labeling and marketing to adolescents. Future research can inspire further research to understand the underlying causes of being overweight among adolescents, such as genetic and environmental factors that can guide the development of interventions to reduce the prevalence of overweight among adolescents, i.e., technology-

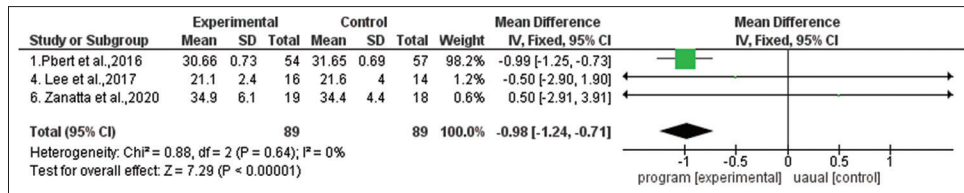


Figure 7: Subgroup analysis of weight control programs for adolescents with overweight and obese focusing on diet and exercise

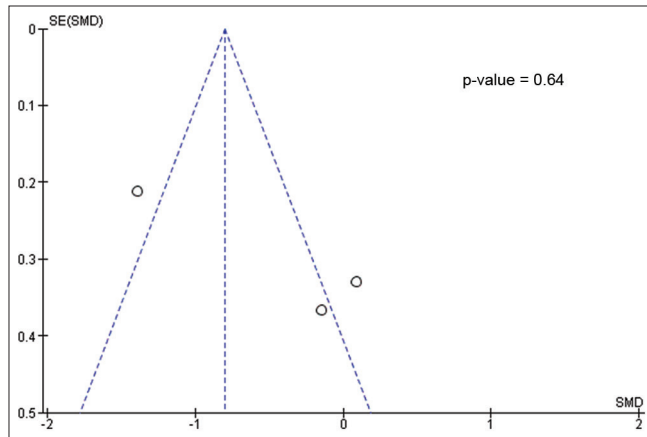


Figure 8: The funnel plot analysis of weight control programs for adolescents overweight and obese focuses on diet and exercise

based interventions or peer-led programs. Also, they can investigate the long-term effects of being overweight during adolescence, i.e., its impact on physical and mental health outcomes later in life.

### Conclusion

Overall, the implications of research on overweight adolescents can have a broad impact on healthcare, education, public health, and policy. Using the findings to inform practice, policy, and future research, we can work to prevent and manage overweight among adolescents and improve their health outcomes.

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### Conflicts of interest

Nothing to declare.

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