Meta-Analysis

INTERVENTION OF PHYSICAL ACTIVITIES IN CHILDREN AND ADOLESCENTS WITH OBESITY IN ASIA: A SYSTEMATIC REVIEW AND META-ANALYSIS

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ABSTRACT

Background: The prevalence of obesity in children and adolescents in developing countries, especially in Asia, is increasing and becomes a significant cause of morbidity and mortality, including in Indonesia.

Objective: This study aims to analyze the intervention of physical activities on BMI, waist circumference, and body fat percentage in overweight/obese children in Asia.

Methods: This study conducted a systematic review and meta-analysis on 4,163 studies comprehensively from electronic databases, including PubMed (MEDLINE), PubMed Central (PMC), Science Direct, Springer Link, Cochrane, and hand searching. The results of data analysis were presented in narration, table, and graphics. A quantitative synthesis of the meta-analysis was conducted using the MedCalc software.

Results: Meta-analysis results showed a significant decrease in body fat percentage after the intervention of physical activities (-1.422, 95% CI, -1.697 to -1.146) with $p < 0.001$. The decrease of BMI z-score after the intervention of physical activities in the meta-analysis showed a significant result (-0.877, 95% CI, -1.170 to -0.585) with $p < 0.001$. There was a significant decrease in waist circumference in overweight/obese children and adolescents (1.111, 95% CI, -1.385 to -0.837) with $p < 0.001$).

Conclusion: There is a significant difference in body fat percentage, BMI z-score, and waist circumference between overweight and obese children and adolescents who received the intervention of physical activities and the control group in Asia.

Keywords: Physical activity, obesity, Asia, Systematic review, Meta-analysis

INTRODUCTION

Obesity is caused by an excess of energy intake compared to the body's needs, which lead to excessive energy accumulation formed by adipose tissues. The prevalence of overweight and obesity in children and adolescents has been increasing within the last decades, with an estimate of 170 million children under 18 years old are overweight or obese in 2008, which is projected to increase by 30% by 2030. The World Health Organization (WHO) estimated a faster increase in overweight and obesity prevalence in developing countries compared to developed countries. A study by Jayawerdana in 2013 reported that the prevalence of obesity in children and adolescents in Asia is the highest in developing countries. Obesity in childhood has a 75% risk in obesity in adulthood.[1,2]

Obesity is related to several metabolism disturbances, including insulin resistance and diabetes mellitus. Although the cause of insulin resistance is multifactorial, obesity has a strong correlation with insulin resistance.

Obesity can be measured by anthropometric measurements, such as body weight, body mass index, and waist circumference. Currently, much literature uses body fat percentages to measure the obesity index. For adolescents and young adults, obesity is a concerning problem because it can reduce self-esteem and cause psychological disorders, which have been widely investigated in Europe[2,3] To date, there have not been many studies that provided intervention in the form of physical activities, especially in overweight/obese adolescents in Asia.

METHODS

This study used a systematic review and meta-analysis design. Articles were searched using PICO; population: children with overweight or obesity, intervention: physical activity treatment, comparison: no physical activity treatment, outcome: decrease body fat percentage, BMI, and waist circumference. This study was conducted in Asia from 2010 to 2020 and met the inclusion and exclusion criteria using a writing recommendation based on (PRISMA-P) 2015.

The process of the literature search was conducted comprehensively using an electronic database from PubMed (MEDLINE), PubMed Central (PMC), Science Direct, Springer Link, and Cochrane Library which discussed studies concerning physical activities on overweight and obese children using a Boolean operator and Medical Subject Headings (MeSH) to focus the search, connecting various information and found the required literature in the search engine. The inclusion criteria include studies with randomized and non-randomized subjects, a minimum of 20 subjects, an intervention of physical activities on children or adolescents with overweight/obesity for at least 4 weeks, and the study is published in English and Indonesian language over a period of 10 years, and the population studied came from Asia. The articles should be full paper with an experimental design, subjects aged > 6 years to < 18 years during observation, and the observation should include the country of where the study took place, method of study, samples, and type of intervention. The results of data analysis were presented in narration, table, and graphics. A quantitative synthesis of the meta-analysis was conducted using the MedCalc software. The results of processing data obtained will be displayed in the form of a forest plot by calculating the p value, with p value < 0.05 having a statistically significant value.

The five studies used in this study measure primary outcomes of body mass index (BMI) and secondary outcomes of waist circumference and body fat percentage after physical activity intervention was given. Research conducted by Anam et al. in 2010 had a one group pre-post test study design in which 20 obese children aged 9-10 years underwent anthropometric measurements and body composition before and after exercise intervention and dietary restrictions for 8 weeks. The exercise intervention was performed 3 times per week, each session approximately 45 minutes with moderate to vigorous intensity. BMI in research subjects after the intervention can decrease significantly by ± 0.7 kg/m2 (p=0.006). However, this output is not a pure result of the exercise intervention, but is also influenced by the daily dietary restriction intervention using a low-cholesterol diet with a calorie target of 1700 kcal/day. Meanwhile, the indicator of body fat percentage did not decrease significantly, although there was a decrease of around 1.2% (p=0.086).[4]

The study by Ahmad et al., has a randomized controlled trial design compares the results of a family-based REDUCE (REorganize Diet, Unnecessary Screen time, and Exercise) intervention program to improve body fat in 67 overweight and obese children compared with 67 children in control group with age 8-11 years. Significant differences can be observed in the body component variables, namely BMI and waist circumference in the exercise intervention group compared to the control group. This study carried out an intervention at least 30 minutes of moderate to vigorous intensity exercise for 3 and 6 months. The measurement results after 3 months of intervention still did not show significant mean differences, including: BMI Z-score of -0.11 (p=0.086), difference in mean waist circumference of -2.19 (p=0.116), and body fat percentage of -0.98 (p=0.209). Meanwhile, after 6 months of intervention, there was a significant difference in the mean of BMI and waist circumference, namely -0.14 (p=0.045) and -3.18 (p=0.021), but the percentage of body fat still showed an insignificant result of -0.50 (p=0.530).[5]

In a study conducted by Seo et al., 70 children and adolescents (6-16 years) with overweight or obesity were divided into two intervention groups, usual care group and exercise group. Usual care group interventions include private medical consultations, workbooks on goals and behavior modification, exercise counseling, monitoring and feedback on physical activity, and nutrition counseling. Meanwhile, the exercise group received the same intervention as the usual care group and received an additional 3 days/week exercise program with 60 minutes each session at 60%-90% maximum heart rate. Anthropometric measurements and body composition were carried out before and after the intervention for 12 weeks. After the intervention lasted 12 weeks there was a significant decrease in BMI z-score in the intervention group exercise group from 2.32 ± 0.52 to 2.24 ± 0.56 (p = 0.03). In addition, there was also a significant decrease in body fat percentage from 32.33 ± 6.38 to 31.64 ± 6.69 (p = 0.17). Meanwhile, in the usual care group intervention group, there was no significant difference between the measurements before and after the intervention, in terms of BMI z-score and body fat percentage. In both intervention groups, there was no significant decrease in waist circumference.[6]

The study conducted by Li et al., had different research objectives, where the sample used was not only children with overweight or obesity. This study seeks to run the CHIRPY DRAGON (Chinese Primary School Children Physical Activity and Dietary Behavior Changes Intervention) program in the form of physical activity interventions and nutritional support for 12 months to prevent obesity in 1,562 elementary school age children in China. The planned physical activity intervention is in the form of activities that have been agreed upon by each school in advance for 1 hour every day entering school and sports or physical games involving parents at home within a period of 12 months. There was a significant difference in the mean BMI z-score between the treatment and control groups of -0.13 ± -0.26 to 0.00 (p=0.048). However, there was no significant difference in the variables of waist circumference and body fat percentage between the treatment and control groups.[7]

The study, conducted by Sun et al., investigated the effect of after-school exercise with or without dietary restriction on obesity in 93 overweight adolescents in China (13.6±0.7 years). Physical activity in the form of aerobic exercise for one hour every day after school, 4 times a week for 10 weeks. The aerobic protocol is a combination of several sports such as jogging, running, jumping rope, basketball, soccer, and badminton which

has a target of 40%-60% of VO2max. The results after 10 weeks of intervention showed a significant decrease in waist circumference (89.9±8.4cm to 81.9±8.5cm, p=0.023) and body fat percentage (32.6±3.9% to 30.0±4.8%, p=0.026) between the exercise groups compared control. However, BMI in the exercise intervention group did not show a significant difference (26.2±2.7 kg/m2 to 25.4±2.7 kg/m2, p=0.942).[8] A general description of the characteristics of the research can be seen in table 4.1.

Regarding the validity of each article, there was no random selection of samples as treatment subjects in Anam et al study. The random distribution list was not hidden in the Seo et al., Li et al. All studies were double blind, the studies did not keep the type of intervention given to research subjects and researchers themselves. Patient observation was completed and according to the initial planning in all studies. All study participants were taken into account in each study, but only the research of Seo et al who still include drop out samples in data analysis as research subjects separately from completers (samples who complete the study to the end). All studies have controlled for confounding factors such as diet and education about behavior change. All studies analyzed the same groups as the original research plan. The risk assessment of research bias used in the meta-analysis can be seen in table 2.

Based on the data presented by each study, a meta-analysis was calculate the mean differences in BMI mean, waist circumference, and body fat percentage between the physical activity intervention group and control group. Only studies by Ahmad et al., Seo et al., and Sun et al., which has a randomized controlled trial design and uses obese or overweight children and adolescents as a subject so that meta-analysis can only uses these three studies.

RESULTS

This systematic review identified 4,163 relevant studies through the search strategy from electronic media and one article from hand searching. (**Figure 1**) showed the process of article selection. As much as 2,473 articles from 2,498 studies were excluded for various reasons, such as only available in the abstract form, use the intervention of medicine, the same subjects, the design was not as expected, and in the form of a review. The remaining 25 articles were selected based on completeness, and 20 articles were excluded because 17 of them were studies with a population outside Asia, and 3 articles had incomplete data. Five experimental studies met the criteria for analysis in this review.

The five studies were conducted in Indonesia, Malaysia, China, and Korea (Asian countries) with the keywords of physical activity, obesity, Asia, systematic review, meta-analysis. The primary outcome used was body mass index (BMI), and the secondary outcomes were waist circumference and body fat percentage after the intervention of physical activities, which can be seen in (**Table 1**).[4,5,6,7,8]

All participants had been calculated in each study. However, only Seo *et al.* included drop-out samples from data analysis as a separate subject from completers (samples who finished the study to the end). All studies had controlled confounding variables, such as diet and education on behavior change. All studies analyzed the same group with the initial study plan. Assessment of bias risk in this meta-analysis can be seen in (**Table 2**). The

difference of primary and secondary outcomes before and after the intervention was assessed from BMI, waist circumference, and body fat percentage. The characteristics of the studies were summarized based on country, method, samples, and intervention, which is presented in (**Table 3**).

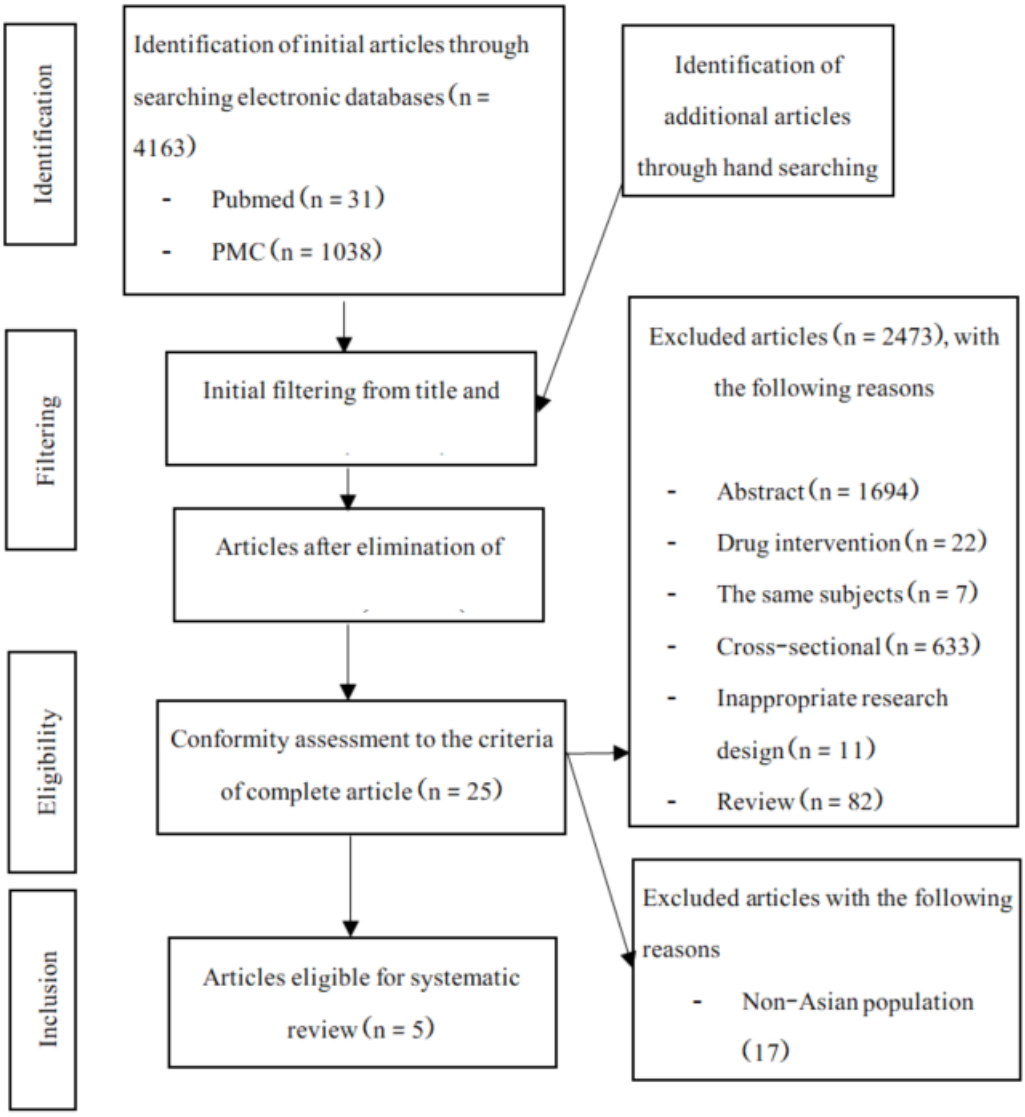

Figure 1. PRISMA flowchart diagram

Based on the presented data from each article, the meta-analysis was conducted to calculate the mean difference of BMI, waist circumference, and body mass percentage between the physical activities intervention group and control group. Only Ahmad *et al.*, Seo *et al.*, and Sun *et al.* used a randomized controlled trial design and conducted the study on obese or overweight children and adolescents. Therefore, meta-analysis can only be performed on these three studies, which is presented in (**Table 4**).

The reduction of BMI z-score after physical activities intervention in this meta-analysis showed a significant result (-0.877, 95% CI, -1.170 to -0.585) according to a previous meta-analysis by George *et al.* on the United

States population in 2018, which found a significant IMT decrease (-0.06, 95% CI, -0.09 to -0.03) from 34 studies comprising of 1,308 participants, as seen in (**Figure 2**).

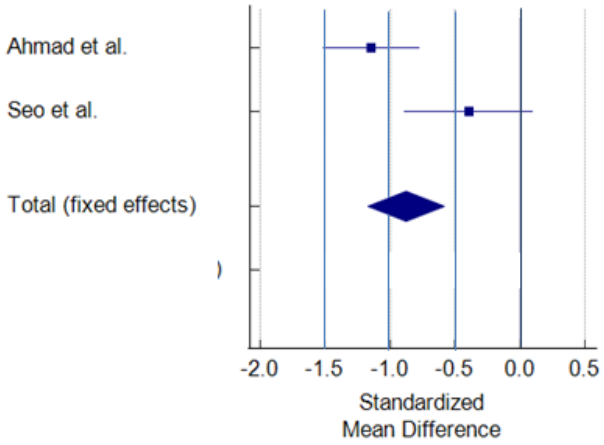

Figure 2. Meta-analysis forest plot from the effect of physical activity intervention on BMI z-score.

The meta-analysis result of waist circumference in overweight and obese children and adolescents in this study showed a significant decrease (-1.111, 95% CI, -1.385 to -0.837). This was in accordance with a previous meta-analysis by Stoner *et al.* in 2016 on American, Australian, European, and Asian population which showed a significant decrease of waist circumference (-0.32, 95% CI, -0.51 to -0.13), and can be seen in (**Figure 3**).

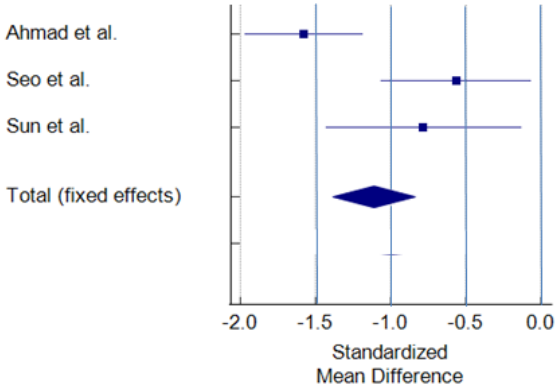

Figure 3. Meta-analysis forest plot from the effect of physical activity intervention on waist circumference.

Body fat percentage decrease was significant in this meta-analysis (-1.422, 95% CI, -1.697 to -1.146). The results were in accordance with a meta-analysis conducted by Bruno *et al.* in Spain in 2018, which investigated the effect of aerobic exercise and physical endurance with the Mediterranean diet and showed an improvement of body composition in obese children and adolescents, including a significant decrease of body fat percentage (-1.8, 95% CI, -3.3 to -0.3), can be seen in (**Figure 4**).

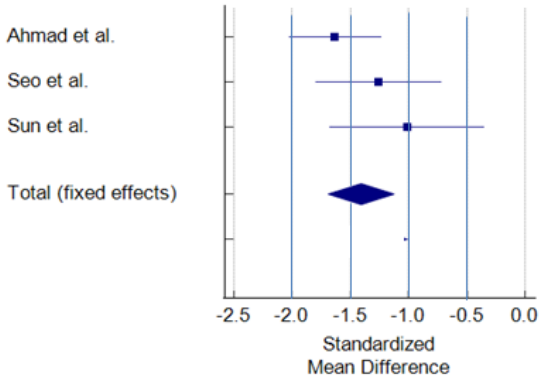

Figure 4. Meta-analysis forest plot from the effect of physical activity intervention on body fat percentage.

Effect sizes analyzed in this meta-analysis include BMI, waist circumference, and body fat percentage, but because the research used is very heterogeneous, it allows for research bias. The overall results support that physical activity or exercise can improve obesity or overweight conditions in children and adolescents seen from the decrease in BMI z-score, waist circumference, and body fat percentage with statistically significant values. Heterogeneity in this study seen from the value of I^2. Heterogeneity in body fat percentage has the lowest I^2 value, namely 14.31% compared to I^2 in BMI and waist circumference with results of 83.4% and 82.5%, respectively.

Table 1. Characteristics of the studies.

Author	Anam et al[4]	Ahmad et al[5]	Seo et al[6]	Li et al[7]	Sun et al[8]
Country	Indonesia	Malaysia	South Korea	China	China
Method	Experimental, *one group pre-, and post-test design*	An experimental, *randomized controlled trial*	Experimental, *two active treatment groups*	An experimental, *randomized controlled trial*	An experimental, *randomized controlled trial*
Samples	20 children with obesity (9-10 years old, 17 boys)	134 children with BMT *z-score* > 1 SD (overweight and obese), divided into treatment group (n = 67; 40 boys; 9.6 years old) and control group (n = 67; 38 boys; 9.6 years old)	70 children and adolescents with overweight or obesity, divided into usual care group (n = 44; 12.39 years old) and exercise group (n = 26; 12.92 years old)	1,562 children, divided into treatment group (n = 794; 6.15 years old) and control group (n = 768; 6.14 years old)	93 adolescents (13.6±0.7 years old) with overweight, divided into 4 groups; diet (n=22, 9 boys), exercise (n=25, 18 boys), diet + exercise (n=29, 12 boys), control (n=17, 7 boys)
Intervention	Exercise intervention in the form of the physical activity program for 3 times a week, for 45 minutes, moderate to vigorous intensity for 8 weeks. Diet intervention in the form of counseling to the children and their parents concerning daily dietary limitation using stage II low cholesterol diet with a target of 1700 kcal/day.	The REDUCE (Reorganize diet, Unnecessary screen time, and Exercise) intervention program implemented on the parents for 6 months with a target of not consuming sugary drinks and unhealthy snack, regulating eating with a minimum of 2 fruits and 3 vegetables, and exercise for at least 30 minutes with moderate to vigorous intensity, and reducing screen time to a maximum of 120 minutes (television and game)	The intervention of the usual care group in the form of private medical consultation, workbook on the objective and behavior modification, exercise counseling, observation and feedback on physical activities, and nutrition counseling. The exercise group received intervention similar to the usual care group, added with a 3 days/week of an exercise program with each session consisting of 60 minutes of exercise on 60%-90% of maximum heart rate for 12 weeks.	The CHIRPY DRAGON (Chinese Primary School Children Physical Activity and Dietary Behavior Changes Intervention) program, which is the intervention of physical activity and nutrition support. The intervention of physical activity in school, in the form of an agreed-upon activity for 1 hour every school day and exercise or physical game involving parents at home for 12 months. Nutrition intervention of reduction of fatty food, the measurement of rice, salt, and sugar, and the provision of vegetables every day for lunch.	Exercise intervention in the form of 60 minutes of aerobic protocol once a day after school, 4 times a week for 10 weeks. Physical activities include the combination of several exercises, such as jogging, running, skipping rope, basketball, volleyball, and badminton. The intensity of physical activities had a target of 40%=60% of VO2max as seen from heart rate.

Table 2. Bias risk in a meta-analysis based on the Cochrane Risk of Bias Assessment Tool

Domain	Ahmad et al.[5]	Seo et al.[6]	Sun et al.[8]
Making a randomized list (selection bias)	Low Risk	Low Risk	Low Risk
Confidentiality of allocation (selection bias)	Low Risk	High Risk	Undetermined risk
Blinding of participants and personnel (performance bias)	Low Risk	High Risk	Undetermined risk
Blinding of outcome rater (performance bias)	Low Risk	Low Risk	Low Risk
Incomplete outcome data (attrition bias)	Low Risk	Low Risk	Low Risk
Incomplete outcome report (reporting bias)	Low Risk	Low Risk	High Risk
Physically active before sampling (other bias)	Undetermined risk	Undetermined risk	Low Risk

Table 3. Differences in primary and secondary outcomes before and after intervention.[4,5,6,7,8]

Parameter	Time	Anam et al	Ahmad et al		Seo et al		Li et al		Sun et al	
		Exercise group	Exercise group	Control group	Usual care group	Exercise group	Exercise group	Control group	Exercise group	Control group
IMT	Before intervention	25,1 ± 2,55 (kg/m2)	2.05 ± 0.40 (z-score)	2.11 ± 0.39 (z-score)	2.32 ± 0.45 (z-score)	2.34 ± 0.54 (z-score)	-0.13 ± 1.30 (z-score)	-0.13 ± 1.30 (z-score)	26.2 ± 2.7 (kg/m2)	27.9 ± 3.8 (kg/m2)
	After intervention	24,5 ± 2,60 (kg/m2)	1.95 ± 0.45 (z-score)	2.09 ± 0.35 (z-score)	2.29 ± 0.53 (z-score)	2.24 ± 0.56 (z-score)	-0.35 ± 1.22 (z-score)	-0.23 ± 1.34 (z-score)	25.4 ± 2.7 (kg/m2)	27.5 ± 3.9 (kg/m2)
Waist circumference	Before intervention	-	90.21 ± 7.98	91.28 ± 7.04	93.43 ± 11.79	97.61 ± 8.59	53.71 ± 5.79)	53.71 ± 5.76	89.8 ± 8.4	87.9 ± 9.9
	After intervention	-	89.37 ± 9.26	92.55 ± 6.20	93.67 ± 13.97	96.32 ± 9.68	57.45 ± 6.82	57.85 ± 6.87	81.9 ± 8.5	82.1 ± 8.9
Body fat percentage	Before intervention	34,40 ± 4,49	37.87 ± 4.20	37.63 ± 4.09	41.26 ± 4.25	41.77 ± 4.23	21.30 ± 6.23	21.53 ± 6.05	32.6 ± 3.9	36.7 ± 4.9
	After intervention	33,20 ± 4,90	36.75 ± 4.75	37.25 ± 4.46	41.05 ± 4.49	40.22 ± 4.62	18.96 ± 5.64	19.95 ± 5.64	30.0 ± 4.8	35.6 ± 5.1

Tabel 4. The results meta-analysis of differences in mean BMI z-scores, waist circumference, and body fat percentage at 95% confidence intervals.[5,6,8]

Researcher	IMT *z-score*				Waist circumference				Body fat percentage			
	Differences in mean	Lower limit	Upper limit	*p*	Differences in mean	Lower limit	Upper limit	*p*	Differences in mean	Lower limit	Upper limit	*P*
Ahmad et al.	-1,150	-1,517	-0,783		-1,576	-1,966	-1,187		-1,634	-2,027	1,241	
Seo et al.	-0,395	-0,888	0,097		-0,565	-1,062	-0,068		-1,261	-1,794	0,729	
Sun et al.	-	-	-		-0,783	-1,430	-0,136		-1,156	-1,740	-0,572	
Total	**-0,877**	**-1,170**	**-0,585**	**<0,001**	**-1,111**	**-1,385**	**-0,837**	**<0,001**	**-1,422**	**-1,697**	**-1,146**	**<0,001**

DISCUSSION

This systematic review aims to analyze the effect of physical activity intervention on several obesity indicators, such as BMI, waist circumference, and body fat percentage in children and adolescents. The study involved 1,879 children and adolescents in four Asian countries. These studies were heterogeneous in design, study, population, and intervention. Therefore, only three articles were eligible for meta-analysis. The difference in intervention results from each study can be seen in Table 4.3.

The effect size analyzed in this meta-analysis include BMI, waist circumference, and body fat percentage. However, due to the heterogeneous nature of the study, bias can occur. Overall results supported that physical activity or exercise can improve the condition of obesity or overweight in children and adolescents, which can be seen from the statistically significant decrease in BMI z-score, waist circumference, and body fat percentage.

A study conducted in five European countries (Spain, Belgium, Germany, Italy, and Poland) concerning physical activities in children found that the average subjects performed moderate-heavy physical activity for 41 minutes every day. Boys performed longer physical activity in a day compared to girls (36 minutes) and obese children (24 minutes). This study concluded that the duration of physical activities performed by children for a day should be 46 minutes. The study also compared the addition of physical activities for 5 minutes, 15 minutes, and 60 minutes for each type of physical activity and concluded that the addition of 15 minutes of heavy physical activity yielded the same effectivity as 60 minutes of moderate-heavy physical activity. The longer the child performs a sedentary activity, the higher the risk of obesity.[9,10]

A study on 26 middle schools in Hongkong provided a SELF FIT (Self-determined Exercise and Learning for FITness) to the students to improve the physical activities from moderate to heavy during physical education and increase their autonomous motivation for fitness activities. This school-based multi-component intervention aims to increase teachers' supportive behaviors to increase the students' physical activity behavior.[11]

WHO recommendation to improve muscle fitness, bone health, heart health, and metabolism recommends that children and adolescents aged 5-17 years old accumulate at least 60 minutes of moderate to heavy physical activities every day. Physical activities of more than 60 minutes provide additional health benefits and most daily physical activity should be aerobic. Sedentary children should start with light activity and gradually increase duration, frequency, and intensity. The concept of accumulation explains that to reach 60 minutes of physical activities a day, someone can divide his activity into several series in a day that can be accumulated to 60 minutes. [12]

CONCLUSION

There was a significant difference in body fat percentage, BMI z-score, and waist circumference in overweight and obese children and adolescents between those with physical activity intervention and control in Asia. Physical activity is important for children to prevent overweight and obesity. Further research needs to be done with minimal research bias.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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