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Impact Of School-Based Intervention Program On The Anthropometric And Eating Habits Of 6-12 Years Overweight Children: A Research Study

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Abstract
Childhood overweight and obesity are escalating public health concerns globally, particularly in developing nations like India. The shift in dietary patterns and lifestyle is contributing factor for the rise in obesity rates among children. This study investigates the impact of a structured school-based intervention program on the eating habits and physical activity patterns of overweight children aged 6 to 12 years. A total of 506 children from Saharanpur and Roorkee were enrolled using purposive sampling. Pre- and post-intervention data were collected on anthropometric measures, dietary habits, and physical activity using standardized tools. The intervention included educational pamphlets, healthy recipe booklets, and interactive sessions. Anthropometric measurements and eating habits improved statistically significantly after the intervention. The mean waist-to-height ratio (WHtR) and the proportion of children with WHtR > 0.5 decreased statistically significantly after the intervention, indicating that the school-based lifestyle program was successful in lowering central adiposity, encouraging better eating habits, and deterring the use of processed and convenience foods. The impact of focused nutrition education in modifying eating behaviours among overweight school-age children was validated by the observed changes, which were statistically significant across all analysed parameters ($p < 0.05$). The findings confirms that school-based- interventions are effective in handling global issue of overweight and obesity in children.

Keywords: Childhood obesity, school-based intervention, dietary habits, Waist-to-Height Ratio, overweight children, nutritional education.

1.INTRODUCTION

The incidence of childhood and teenage obesity and overweight is a major global health concern [1]. Serious chronic diseases might undoubtedly result from these situations if they exist during childhood and adolescence [2, 3]. Serious outcomes like diabetes, cardiovascular disease, and some types of cancer might arise when these problems continue into adulthood [4,5,6].

Consequently, it is crucial for the prevention of health diseases to monitor children's weight status [7]. A lack of physical exercise and an excessive consumption of calories are major contributors to the epidemic of childhood obesity, while there are other modifiable lifestyle factors at play as well [8, 9].

Healthy diets should be given priority because of the high incidence of diet-related conditions in children and adolescents, such as diabetes and obesity, as well as the significance of dietary factors in relation to childhood obesity [8, 9,10,11]. Rather than eating a diet full of fruits and vegetables, many kids snack on foods high in saturated fat, sugar, and calories, which can cause them to gain weight [12,13, 14, 15]. According to research, children's incapacity to keep a healthy body weight is exacerbated by a vicious loop that starts when they are assumed to engage in risky behaviours, like eating unhealthy foods, while they are not moving around [16, 17]. Both physical inactivity and sedentary/unhealthy behaviours increase the likelihood of childhood overweight or obesity [18,19,20]. As a result, earlier studies have looked at how food and exercise affect kids [21, 22]. Given the aforementioned, Tabacchi et al. [21] suggested that improving food literacy and, consequently, academic achievement can be achieved by fostering an environment that supports children's growth in both motor and cognitive skills.

Anthropometric, cardio and metabolic risk variables were reduced by a number of lifestyle interventions [20, 23,24, 25, 26] and to improve body image satisfaction [27]. However, only a small number of treatments have included food quality [28, 29]. Unfortunately, behavioural treatment for weight often

has a limited and temporary impact on children, and they are often hesitant to comply with exhortational behaviour's [30,31,32].

School based intervention programs help students define and maintain a healthy lifestyle play a crucial role in improving their mental health and cognitive functioning, especially when children spend so much time in school [33,34,35]. However, controlling food intake, increasing physical activity, and decreasing sedentary behaviour are all parts of an interdisciplinary strategy for preventing obesity. It is commonly known that school-based interventions can effectively lower childhood obesity.

Despite these promising results, gaps remain in the widespread implementation and evaluation of effective school-based interventions, especially regarding their duration, scalability, and ability to maintain positive outcomes beyond the intervention period [36,37].

School-based interventions have been shown to be successful in treating childhood obesity, according to compelling data [38]. The interventions implemented in schools as reported in the literature were highly diverse. The goal of these programs was to reduce obesity through encouraging more exercise, discouraging less sedentary behaviour, and reducing consumption of foods high in fat and sugar. Lessons and/or physical education classes were the means of program delivery. Many programs consist of multiple components. However, there is currently very little data on obesity prevention and the best public health interventions for this purpose [39]. Little is known about the impact, scope, and mechanism of obesity prevention programs, especially in a developing nation like India.

Therefore, research studies focusing on the impact of these programs—specifically targeting anthropometric and eating habits among overweight children aged 6–12 years—are critical for building the evidence base needed to inform policy and best practices.

The purpose of this study is to evaluate the efficacy of a comprehensive school-based intervention program in improving both the anthropometric measures and eating behaviours of overweight children in the primary school age group, thereby contributing valuable insights to the ongoing global effort to curb childhood obesity.

2.Objective

The primary objective of this research study is to access the effectiveness of a school-based intervention program in improving the anthropometric measures and dietary habits of overweight children aged 6–12 years.

3. METHODOLOGY

This study employed a pre-post intervention design to evaluate the impact of a school-based intervention program on the anthropometric and dietary behaviours of overweight children aged 6–12 years. The current study was conducted in the urban districts of Saharanpur (Uttar Pradesh) and Roorkee (Uttarakhand), India.

3.1 Study Setting and Participant Selection

A total of four primary schools—two each from Saharanpur and Roorkee—were purposively selected for the intervention. From these schools, 506 overweight children (aged 6–12 years) were selected for participation. Selection of the children was based on anthropometric assessments (e.g., weight, height, BMI, WC, WHtR), using recognised development reference norms for children (such as the WHO Growth Standards 2007). Children identified as overweight according to the adopted growth standard were included in the study, while those with any medical conditions or receiving other weight management interventions were excluded.

3.2 Distribution of Participants

Of the 506 participants, 322 were from Saharanpur and 184 were from Roorkee. The cohort comprised 286 boys and 220 girls, ensuring a balanced gender representation for sex-based analysis.

3.3 Intervention Program

A structured, school-based intervention was implemented across the selected schools. The program integrated components such as pamphlets outlining the significance of physical activity, nutritious food, nutrition education (conducted by trained educators), behaviour modification sessions, and parent-teacher engagement activities, which were done through guest lectures to promote healthy eating and active lifestyles. A cookbook (Healthy Bites in Kitchen) featuring healthy and quick-to-prepare recipes (particularly healthier/nutritious snacks and tiffin items) with their nutritional facts was also given to the parents. The intervention was delivered over a specified period (3 months), with regular follow-up assessments.

3.4 Data Collection

Baseline (pre-intervention) anthropometric measurements (height, weight, BMI, waist circumference and waist height ratio) and dietary habits (assessed via standardized food frequency questionnaires and 24-hour dietary recalls) were collected for all participants. To evaluate changes, the same measurements were taken again right after the intervention (post-intervention).

3.5 Statistical Analysis

Appropriate statistical techniques were used to examine the data before and after the intervention (e.g., paired t-tests, chi-square tests, and multivariate regression) to determine the significance of changes in anthropometric indicators and eating behaviours. SPSS software version 25 facilitated the statistical computations.

3.6 Ethical Consent

All participants' parents or guardians gave their informed consent, and the appropriate institutional review board granted ethical approval. Data were anonymized and confidentiality was maintained throughout the study.

4. RESULT

4.1 Demographic Profile Children aged 6 to 12 were evenly distributed by gender and location. Most belonged to middle-income families with access to packaged and fast foods.

Table 4.1 Age Wise Distribution of 6 to 12 Years Old School Going Children (n = 506)

Age Group (Mean Age)	Boys (Saharanpur)	Boys (Roorkee)	Girls (Saharanpur)	Girls (Roorkee)	Total
7.4±0.3 yrs	20	12	12	6	50
8.5±0.3 yrs	34	58	22	36	150
9.3±0.3 yrs	76	66	78	44	264
Total	130	136	112	86	**506**

Table 4.1 reveals the age-wise distribution of the 506 school-going children (aged 6–12 years) shows that the maximum number of participants belonged to the older age group of 9.3±0.3 years (n=264, 52.17%), followed by 8.5±0.3 years (n=150, 29.64%) and 7.4±0.3 years (n=50, 9.88%). Boys (n=266) slightly outnumbered girls (n=240), and representation from Roorkee (n=264) was marginally higher than Saharanpur (n=242). Among boys, the highest number were from Saharanpur (n=130), while among girls, the highest number were from Saharanpur as well (n=112). According to the distribution, older children were more likely to participate, which could yield more accurate information about study-relevant behavioural patterns and lifestyle characteristics.

4.2 Changes in the Anthropometric parameters (WHtR) post-intervention data revealed:

Anthropometric indicators such as Body Mass Index (BMI), Waist Circumference (WC) and Waist-to-Height Ratio (WHtR) were measured during pre-intervention, showing high prevalence rate of overweight i.e. 18.3 % in Saharanpur and 13% in Roorkee which leads to overall Prevelance rate to 16.4%. Since the age group exhibits notable changes in their bodies, there were no changes in the average BMI values following the intervention. So WHtR values, an important predictor of central obesity and cardiovascular risk, was monitored that showed declined, indicating a healthier fat distribution among the children. These improvements underline the effectiveness of the intervention in reducing adiposity and preventing further progression toward obesity-related complications.

Table 4.2 Changes in the anthropometric measurements in the children

Boys				Girls			
Age (years)	WHtR (Pre)	WHtR (Post)	% Change in WHtR	Age (years)	WHtR (Pre)	WHtR (Post)	% Change in WHtR
6	0.473	0.461	-2.54	6	0.460	0.454	-1.30
7	0.488	0.480	-1.64	7	0.482	0.472	-2.07
8	0.483	0.478	-1.03	8	0.457	0.449	-1.75
9	0.512	0.499	-2.54	9	0.476	0.466	-2.10
10	0.458	0.452	-1.31	10	0.461	0.454	-1.52
11	0.463	0.452	-2.38	11	0.480	0.472	-1.67

12	0.466	0.460	-1.29	12	0.506	0.496	-1.98

The table 4.2 presents age-wise changes in Waist-to-Height Ratio (WHtR) among boys and girls aged 6 to 12 years following the intervention. A reduction in WHtR was monitored across all age groups in both genders, indicating improvement in central adiposity. Among boys, the highest percentage reduction in WHtR was seen at ages 6 and 9 years (both -2.54%), followed by age 11 (-2.38%). For girls, the greatest reduction was at age 9 (-2.10%) and age 12 (-1.98%). These findings imply that the school-based intervention had a favourable impact on the distribution of abdominal fat in both boys and girls, with a slightly more pronounced effect in younger boys and older girls. Overall, the consistent decline in WHtR across all age groups supports the effectiveness of the program in reducing obesity-related anthropometric risk factors.

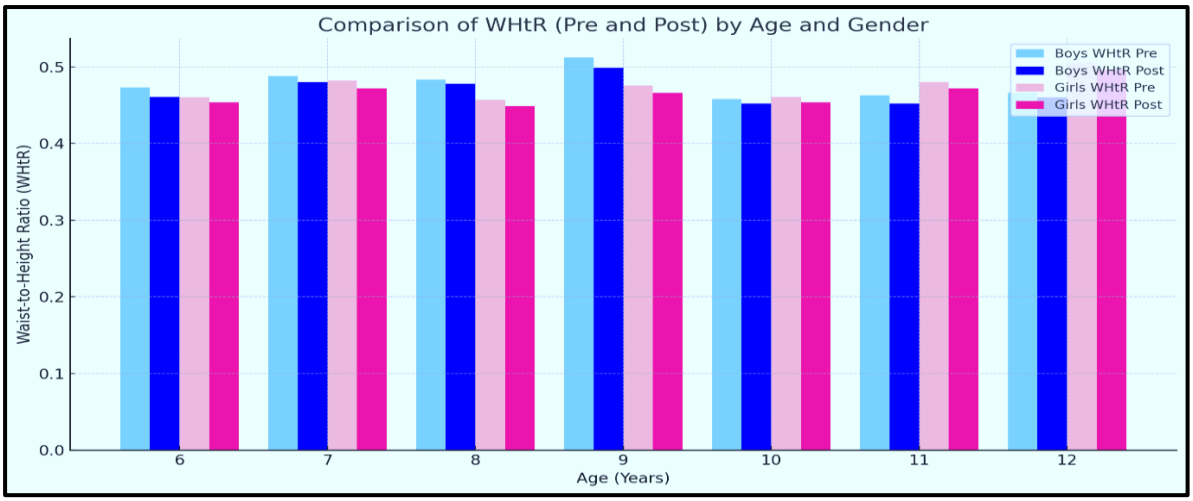

Figure 1 This bar chart presents the pre- and post-intervention WHtR values for boys and girls across different ages

4.2 Changes in Eating Habits Post-intervention data revealed:

A discernible rise in the children's daily consumption of fruits and vegetables, reflecting a positive shift toward nutrient-dense, fiber-rich foods. Many participants who previously skipped vegetables or consumed minimal fruits reported incorporating them into both school and home meals more consistently.

A substantial decrease in the consumption of fast foods, processed snacks, and sugary beverages such as aerated drinks and packaged juices. Children preferred home-cooked meals and were more conscious of the negative health effects of junk food.

Marked improvement in the quality and frequency of breakfast consumption. Children who had previously skipped breakfast or consumed nutrient-poor items like packaged snacks began consuming balanced morning meals, including whole grains, milk, and fruit. The regularity of breakfast intake was also positively affected, contributing to better overall energy levels and concentration in school.

Table 4.3 Changes in the Eating Habits (Packed Lunch)

Criteria	At the Time of Study (n=336) (%)	Follow up 3 after months) (n=336) (%)	Difference (%)	Test value
Healthier meals as per the weekly menu (3 times/ week)	59 (17.4)	88 (26.35)	8.95 ↑	z= 2.82 p=0.0048*
Healthier meals as per the weekly menu (1 to 2 times/ week)	85 (25.3)	112.56 (33.5)	8.2 ↑	z = 2.34 p=0.0191*
Fruit (3t/ week)	18 (5.3)	45 (13.5)	8.2 ↑	z = 3.68 p=0.0002*

Fruit (1 to 2t/ week)	36 (10.7)	94 (27.9)	17.2 ↑	**z = 5.79 p=0.0000***
Packaged snacks/ junk food items in tiffin (>2 or 2 times/ week)	143 (42.7)	79 (23.6)	19.1↓	**z = -5.37 p=0.0000***
Bread/ burger/ noodles and other refined cereal products (>2 or 2 times/ week)	181 (53.9)	111 (32.9)	21 ↓	**z =-5.62 p=0.0000***
Skipping Packed Lunch (>2 or 2 times/ week)	**120 (35.6)**	**58 (17.3)**	**18.3 ↓**	**Z=-5.50 P=0.0000***

- **Note:** Figures in parentheses denote percentage. *Statistically significant using Two Proportion z-test

Healthier food items included meals as per the menu. Inclusion of fruits, salad, curd in the packed tiffin was considered to be a healthy practice. Junk food items included fried foods like samosa, French fries, pooris, chips, biscuits, namkeen, bread butter, bread jam.

The table 4.3 reflects significant positive changes in the eating habits of children with regard to their packed lunch over a period of three months following the intervention. There was a a statistically significant rise in the population of children bringing healthier meals as per the weekly menu at least three times a week, rising from 17.4% to 26.35% (↑8.95%, z = 2.82, p = 0.0048), and those following the menu 1–2 times a week also increased from 25.3% to 33.5% (↑8.2%, z = 2.34, p = 0.0191).

Similarly, fruit consumption showed a marked improvement. Children bringing fruits in their lunch 3 times per week increased from 5.3% to 13.5% (↑8.2%, z = 3.68, p = 0.0002), and those bringing fruits 1–2 times a week rose significantly from 10.7% to 27.9% (↑17.2%, z = 5.79, p = 0.0000).

On the contrary, unhealthy lunchbox habits declined notably. The inclusion of packaged snacks/junk foods dropped from 42.7% to 23.6% (↓19.1%, z = -5.37, p = 0.0000), while consumption of refined cereal products like bread, noodles, and burgers declined from 53.9% to 32.9% (↓21%, z = -5.62, p = 0.0000). Moreover, the number of children skipping packed lunch more than twice a week reduced significantly from 35.6% to 17.3% (↓18.3%, z = -5.50, p = 0.0000).

These statistically significant changes in the eating habits indicate that the intervention was effective in promoting healthier lunchbox practices, reducing reliance on junk foods and encouraging regular, nutritious meals among school-going children.

5.Discussion

The present study aimed to assess the impact of a school-based intervention program on the eating habits and anthropometric profiles of overweight school-going children aged 6 to 12 years. The results indicate significant improvements in both the nutritional behaviours and central adiposity indicators of the participants over the three-month intervention period.

5.1 Anthropometric Improvements (WHtR Reduction)

Waist-to-Height Ratio (WHtR) was used as a key anthropometric indicator to assess abdominal obesity [45], which is considered a more sensitive and age-independent measure of cardiovascular risk in children than BMI [43,44]. For both boys and girls, a steady decline in WHtR was seen in all age groups. Among boys, the highest reduction was noted at ages 6 and 9 (-2.54%), while for girls, it was most significant at ages 9 (-2.10%) and 12 (-1.98%). These findings indicate a positive trend in reducing central fat accumulation, possibly due to improved dietary choices and increased physical activity following counselling and intervention.

The reduction in WHtR, even though numerically modest, is clinically meaningful as it reflects a decrease in abdominal fat, a primary contributor to metabolic disorders in children. These changes support earlier findings that behavioural and dietary interventions in school settings can influence anthropometric outcomes when implemented systematically [40,41].

5.2 Improvements in Eating Habits (Packed Lunch Behaviour)

Table 4.3 highlights substantial changes in the children's packed lunch habits, reflecting healthier food choices post-intervention. The percentage of children bringing healthier meals based on the recommended weekly menu increased significantly (from 17.4% to 26.35% for three times/week and from 25.3% to 33.5% for one to two times/week). Fruit inclusion also improved markedly (from 5.3%

to 13.5% for three times/week and from 10.7% to 27.9% for one to two times/week), which demonstrates increased awareness among children and parents about the nutritional benefits of fruits.

Concurrently, there was a significant decline in unhealthy food practices, including the consumption of packaged snacks/junk foods (from 42.7% to 23.6%) and refined cereals such as bread, burgers, and noodles (from 53.9% to 32.9%). The habit of skipping packed lunch also declined sharply (from 35.6% to 17.3%), indicating improved meal regularity and reduced risk of nutrient deficiencies.

These results are consistent with earlier literature suggesting that nutrition education, practical tools (like meal planning guides), and regular reinforcement in school environments can significantly modify children's food choices and encourage the adoption of healthier eating patterns [42]. The decrease in junk food intake and increase in fruit consumption not only reflect better knowledge but also behavioural adoption—an essential aspect of sustainable lifestyle change.

Overall Impact and Implications

The observed improvements in anthropometric indicators and eating habits suggest that the intervention was successful in addressing important modifiable risk factors for childhood obesity and overweight. The school-based approach, complemented by tools like recipe books, pamphlets, and physical activity promotion, appears to have effectively influenced both children and their families.

Such results reinforce the need for early, structured, and repeated interventions in school settings to promote healthy behaviour's [47,48]. Furthermore, the statistically significant changes across multiple indicators provide strong evidence for incorporating comprehensive nutrition education and behavioural strategies into the school curriculum as a preventive strategy against childhood obesity.

6. Conclusion

The results of this study show that a systematic, school-based intervention program that emphasizes lifestyle adjustment and nutrition education can greatly enhance the anthropometric results and health behaviors of overweight school-age children between the ages of 6 and 12 [46,49,50]. The intervention led to measurable reductions in Waist-to-Height Ratio (WHtR), indicating decreased central adiposity, and was linked to notable changes in eating patterns, particularly the increased consumption of fruits and healthier meals, and a marked decline in the intake of junk food and refined cereals.

The positive behavioural shifts in packed lunch practices and the reduced frequency of meal skipping suggest that children and their families not only absorbed the educational content but also adopted healthier daily routines. The promise of early and ongoing interventions in changing risk variables linked to childhood obesity is highlighted by these statistically and clinically significant reductions.

In conclusion, this study highlights the importance of incorporating practical, age-appropriate, and context-specific strategies—such as nutrition education, engaging tools (recipe books, pamphlets), and school involvement—to promote long-term healthy eating habits and physical activity in children. Such preventive measures, if implemented widely, can contribute meaningfully to the reduction of childhood obesity and the promotion of lifelong health and well-being.

7. Recommendations

- Integrate nutrition education into the school curriculum using interactive tools.
- Conduct regular parent awareness sessions to support healthy eating at home.
- Monitor children's anthropometric data periodically in schools.
- Promote healthy packed lunch policies with weekly menus.
- Train teachers to support healthy behaviours in children.
- Work together with medical experts to ensure successful implementation.
- To evaluate long-term effects, carry out follow-up investigations.

8. Limitations

- Short follow-up period limited assessment of long-term changes.
- Study was restricted to urban areas, affecting generalizability.
- No control group to compare intervention effects.
- Variation in home environment and parental support among participants.

REFERENCES

1. NCD Risk Factor Collaboration (NCD-RisC). Worldwide trends in body mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128.9 million children, adolescents, and adults. Lancet. (2017) 390:2627–42. doi: 10.1016/S0140-6736(17) 32129-3

2. Biro FM, Wien M. Childhood obesity and adult morbidities. Am J Clin Nutr. (2010) 91:1499–505. doi: 10.3945/ajcn.2010.2 8701B
3. Reinehr T, Tittel SR, Holle R, Wiegand S, Gellhaus I, Hebebrand J, et al. Comparison of cardiovascular risk factors between children and adolescents with classes III and IV obesity: findings from the APV cohort. Int J Obes (Lond). (2021) 45:1061–73. doi: 10.1038/s41366-021-00773-x
4. Nejat EJ, Polotsky AJ, Pal L. Predictors of chronic disease at midlife and beyond—the health risks of obesity. Maturitas. (2010) 65:106–11. doi: 10.1016/j.maturitas.2009.09.006
5. Guh DP, Zangh W, Bansback N, Amarsi Z, Birmingham CL, Anis AH, et al. The incidence of co-morbidities related to obesity and overweight: a systematic review and meta-analysis. BMC Public Health. (2009) 9:88. doi: 10.1186/1471-2458-9-88
6. Van Kruijsdijk RC, Van der Wall E, Visseren FL. Obesity and cancer: the role of dysfunctional adipose tissue. Cancer Epidemiol Biomarkers Prev. (2009) 18:2569–78. doi: 10.1158/1055-9965.EPI-09-0372
7. Li K, Haynie D, Lipsky L, Palla H, Iannotti RJ, Simons-Morton B, et al. Assessment of adolescent weight status: similarities and differences between CDC, IOTF, and WHO references. Prev Med. (2016) 87:151–4. doi: 10.1016/j.ypmed.2016.02.035
8. Ingle L, Sleap M, Tolfrey K. The effect of a complex training and detraining programme on selected strength and power variables in early pubertal boys. J Sports Sci. (2006) 24:987–97. doi: 10.1080/02640410500457117
9. Van der Heijden GJ, Wang ZYJ, Chu ZL. Strength exercise improves muscle mass and hepatic insulin sensitivity in obese youth. Med Sci Sports Exerc. (2010) 42:1973–80. doi: 10.1249/MSS.0b013e3181df16d9
10. Kim J, Lim H. Nutritional management in childhood obesity. J Obes Metab Syndr. (2019) 28:225–35. doi: 10.7570/jomes.2019.28.4.225
11. Nishtar S, Gluckman P, Armstrong T. Ending childhood obesity: a time for action. Lancet. (2016) 387:825–7. doi: 10.1016/S0140-6736(16)00140-9
12. Hörmann-Wallner M, Krause R, Alfaro B, Jilani H, Laureati M, Almli VL, et al. Intake of fibre-associated foods and texture preferences in relation to weight status among 9-12 years old children in 6 European countries. Front Nutr. (2021) 18:633807. doi: 10.3389/fnut.2021.633807
13. Giménez-Legarre N, Miguel-Berges ML, Flores-Barrantes P, Santaliestra Pasías AM, Moreno LA. Breakfast characteristics and its association with daily micronutrients intake in children and adolescents-a systematic review and meta-analysis. Nutrients. (2020) 12:3201. doi: 10.3390/nu12 103201
14. Heald FP. Fast food and snack food: beneficial or deleterious. J Adolesc Health. (1992) 13:380–3. doi: 10.1016/1054-139X(92)90033-8
15. Albertini A, Tripodi A, Fabbri A, Mattioli M, Cavrini G, Cecchetti R, et al. Prevalence of obesity in 6- and 9-year-old children living in Central-North Italy Analysis of determinants and indicators of risk of overweight. Obes Rev. (2008) 9:4–10. doi: 10.1111/j.1467-789X.2007.00414.x
16. Pagani LS, Fitzpatrick C, Barnett TA, Dubow E. Prospective associations between early childhood television exposure and academic, psychosocial, and physical well-being by middle childhood. Arch Pediatr Adolesc Med. (2010) 164:425–31. doi: 10.1001/archpediatrics.2010.50
17. Eichinger M, Schneider S, De Bock F. Subjectively and objectively assessed social and physical environmental correlates of preschoolers' accelerometer-based physical activity. Int J Behav Nutr Phys Act. (2017) 14:153. doi: 10.1186/s12966-017-0577-9
18. Hills AP, Andersen LB, Byrne NM. Physical activity and obesity in children. Br J Sports Med. (2011) 45:866–70. doi: 10.1136/bjsports-2011-090199
19. Reilly JJ, Hughes AR, Gillespie J, Malden S, Martin A. Physical activity interventions in early life aimed at reducing later risk of obesity and related non communicable diseases: a rapid review of systematic reviews. Obes Rev. (2019) 20 Suppl 1:61–73. doi: 10.1111/obr.12773
20. Battaglia G, Giustino V, Tabacchi G, Lanza M, Schena F, Biino V, et al. Interrelationship between age, gender, and weight status on motor coordination in Italian children and early adolescents aged 6-13 years old. Front Pediatr. (2021) 965:738294. doi: 10.3389/fped.2021.738294
21. Tabacchi G, Battaglia G, Alesi M, Paoli A, Palma A, Bellafiore M, et al. Food literacy predictors and associations with physical and emergent literacy in pre schoolers: results from the training-to-health project. Public Health Nutr. (2020) 23:356–65. doi: 10.1017/S1368980019002404
22. Obradovic Salcin L, Karin Z, Miljanovic Damjanovic V, Ostojic M, Vrdoljak A, Gilic B, et al. Physical activity, body mass, and adherence to the Mediterranean diet in preschool children: a cross-sectional analysis in the split Dalmatia county (Croatia). Int J Environ Res Public Health. (2019) 16:3237. doi: 10.3390/ijerph16183237
23. Bonavolontà V, Cataldi S, Maci D, Fischetti F. Physical activities and enjoyment during the lockdown: effect of home-based supervised training among children and adolescents. J Human Sport Exerc. (2020) 15:1338–43. doi: 10.14198/jhse.2020.15.Proc4.31
24. Ojeda-Rodríguez A, Morell-Azanza L, Azcona-Sanjulián MC, Martínez JA, Ramírez MJ, Marti A, et al. Reduced serotonin levels after a lifestyle intervention in obese children: association with glucose and anthropometric measurements. Nutr Hosp. (2018) 35:279–85. doi: 10.20960/nh.1439
25. Morell-Azanza L, García-Calzón S, Rendo-Urteaga T, Martin-Calvo N, Chueca M, Martínez JA, et al. Serum oxidized low-density lipoprotein levels are related to cardiometabolic risk and decreased after a weight loss treatment in obese children and adolescents. Pediatr Diabetes. (2016) 18:392–8. doi: 10.1111/pedi.12405
26. De Miguel-Etayo P, Moreno LA, Santabarbara J, Martín-matillas M, Piqueras MJ, Rocha-silva D, et al. Anthropometric indices to assess body-fat changes during a multidisciplinary obesity treatment in adolescents: EVASYON Study. Clin Nutr. (2015) 34:523–8. doi: 10.1016/j.clnu.2014.06.004
27. Latino F, Greco G, Fischetti F, Cataldi S. Multilateral training improves body image perception in female adolescents. J Hum Sport Exerc. (2019) 14(Proc4):S927–36. doi: 10.14198/jhse.2019.14.Proc4.55
28. Waling M, Lind T, Hernell O, Larsson CA. one-year intervention has modest effects on energy and macronutrient intakes of overweight and obese Swedish children. J Nutr. (2010) 140:1793–8. doi: 10.3945/jn.110.125435

29. Waling M, Larsson C. Improved dietary intake among overweight and obese children followed from 8 to 12 years of age in a randomised controlled trial. J Nutr Sci. (2012) 1:1–11. doi: 10.1186/s13052-022-01205-w
30. Nicolucci A, Maffeis C. The adolescent with obesity: what perspectives for treatment? Ital J Pediatr. (2022) 48:9.
31. Beamish A J, Reinehr T. Should bariatric surgery be performed in adolescents? Eur J Endocrinol. (2017) 176:D1–D15. doi: 10.1530/EJE-16-0906
32. Knop C, Singer V, Uysal Y, Schaefer A, Wolters B, Reinehr T, et al. Extremely obese children respond better than extremely obese adolescents to lifestyle interventions. Pediatr Obes. (2015) 10:7–14. doi: 10.1111/j.2047-6310.2013.0 0212.x
33. Greco G, Cataldi S, Fischetti F. Karate as anti-bullying strategy by improvement resilience and self-efficacy in school-age youth. J Phys Educ Sport. (2019) 19:1863–70. doi: 10.7752/jpes.2019.s5276
34. Von Hippel PT, Powell B, Downey DB, Rowland NJ. The effect of school on overweight in childhood: gain in body mass index during the school year and during summer vacation. Am J Public Health. (2007) 97:696–702. doi: 10.2105/AJPH.2005.080754
35. Ip P, Ho FK, Louie LH, Chung TW, Cheung YF, Lee SL, et al. Childhood obesity and physical activity friendly school environments. J Pediatr. (2017) 191:110–6. doi: 10.1016/j.jpeds.2017.08.017
36. Ho TJH, Cheng LJ, Lau Y. School-based interventions for the treatment of childhood obesity: a systematic review, meta-analysis and meta-regression of cluster randomised controlled trials. Public Health Nutr. 2021 Jul;24(10):3087-3099. doi: 10.1017/S1368980021001117. Epub 2021 Mar 22. PMID: 33745501; PMCID: PMC9884753.
37. Thakur JS, Bharti B, Tripathy JP, Dhawan V, Bhansali A. Impact of 20 Week Lifestyle Intervention Package on Anthropometric Biochemical and Behavioral Characteristics of Schoolchildren in North India. J Trop Pediatr. 2016 Oct;62(5):368-76. doi: 10.1093/tropej/fmw020. Epub 2016 Apr 22. PMID: 27105646; PMCID: PMC5040831.
38. 6 Gonzalez-Suarez C, Worley A, Grimmer-Somers K, et al. School-based interventions on childhood obesity: a meta-analysis. Am J Prev Med 2009;37:418–27. [DOI] [PubMed] [Google Scholar]
39. 7Gortmaker SL, Swinburn BA, Levy D, et al. Changing the future of obesity: science, policy, and action. Lancet 2011;378:838–47. [DOI] [PMC free article] [PubMed] [Google Scholar].
40. Dunford LJ, Langley-Evans SC, McMullen S. Childhood obesity and risk of the adult metabolic syndrome: a systematic review. Int J Obes (Lond). 2012 Jan;36(1):1-11. doi: 10.1038/ijo.2011.186. Epub 2011 Nov 1. PMID: 22041985; PMCID: PMC3255098.
41. Bull FC, Al-Ansari SS, Biddle S, Borodulin K, Buman MP, Cardon G, Carty C, Chaput JP, Chastin S, Chou R, Dempsey PC, DiPietro L, Ekelund U, Firth J, Friedenreich CM, Garcia L, Gichu M, Jago R, Katzmarzyk PT, Lambert E, Leitzmann M, Milton K, Ortega FB, Ranasinghe C, Stamatakis E, Tiedemann A, Troiano RP, van der Ploeg HP, Wari V, Willumsen JF. World Health Organization 2020 guidelines on physical activity and sedentary behaviour. Br J Sports Med. 2020 Dec;54(24):1451-1462. doi: 10.1136/bjsports-2020-102955. PMID: 33239350; PMCID: PMC7719906.
42. Karnik S, Kanekar A. Childhood obesity: a global public health crisis. Int J Prev Med. 2012 Jan;3(1):1-7. PMID: 22506094; PMCID: PMC3278864.
43. Maffeis C, Banzato C, Talamini G; Obesity Study Group of the Italian Society of Pediatric Endocrinology and Diabetology. Waist-to-height ratio, a useful index to identify high metabolic risk in overweight children. J Pediatr. 2008 Feb;152(2):207-13. doi: 10.1016/j.jpeds.2007.09.021. Epub 2007 Nov 19. PMID: 18206690.
44. Kuba, V.M., Leone, C. & Damiani, D. Is waist-to-height ratio a useful indicator of cardio-metabolic risk in 6-10-year-old children?. BMC Pediatr 13, 91 (2013). https://doi.org/10.1186/1471-2431-13-91
45. Roy, S. K., Kaushik, R. . V., & Patel, A. V. (2025). Waist-To-Sitting Height Ratio as A Predictor of Cardiometabolic Risk in Children: A Comparative Analysis with Body Mass Index. National Journal of Medical Research, 15(02), 139–144. https://doi.org/10.55489/njmr.150220251089
46. Singhal N, Misra A, Shah P, Gulati S. Effects of controlled school-based multi-component model of nutrition and lifestyle interventions on behavior modification, anthropometry and metabolic risk profile of urban Asian Indian adolescents in North India. Eur J Clin Nutr. 2010 Apr;64(4):364-73. doi: 10.1038/ejcn.2009.150. Epub 2010 Jan 20. PMID: 20087379.
47. Brown T, Moore TH, Hooper L, Gao Y, Zayegh A, Ijaz S, Elwenspoek M, Foxen SC, Magee L, O'Malley C, Waters E, Summerbell CD. Interventions for preventing obesity in children. Cochrane Database Syst Rev. 2019 Jul 23;7(7):CD001871. doi: 10.1002/14651858.CD001871.pub4. PMID: 31332776; PMCID: PMC6646867.
48. Waters E, de Silva-Sanigorski A, Hall BJ, Brown T, Campbell KJ, Gao Y, Armstrong R, Prosser L, Summerbell CD. Interventions for preventing obesity in children. Cochrane Database Syst Rev. 2011 Dec 7;(12):CD001871. doi: 10.1002/14651858.CD001871.pub3. Update in: Cochrane Database Syst Rev. 2019 Jul 23;7:CD001871. doi: 10.1002/14651858.CD001871.pub4. PMID: 22161367.
49. Safdie M, Jennings-Aburto N, Lévesque L, Janssen I, Campirano-Núñez F, López-Olmedo N, Aburto T, Rivera JA. Impact of a school-based intervention program on obesity risk factors in Mexican children. Salud Publica Mex. 2013;55 Suppl 3:374-87. doi: 10.21149/spm.v55s3.5138. PMID: 24643486.
50. Marsigliante S, Ciardo V, Di Maglie A, My G and Muscella A (2022) Efficacy of school-based intervention programs in reducing overweight: A randomized trial. Front. Nutr. 9:1001934. doi: 10.3389/fnut.2022.1001934