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RESEARCH ARTICLE

Effectiveness of School-Based Interventions in Reducing Childhood Obesity: A Community Medicine Perspective

A.S. Nizamudeen[1], Shibina Shajahan[2], Logeswari J[3], Shankar K[4], Fabiola M Dhanraj[5] and Chamundeeswari D[6]

[1]Department of Community Medicine, Meenakshi Medical College Hospital & Research Institute, Meenakshi Academy of Higher Education and Research
[2]Department of Community Medicine, Meenakshi Medical College Hospital & Research Institute, Meenakshi Academy of Higher Education and Research
[3]Department of Oral Pathology, Meenakshi Ammal Dental College and Hospital, Meenakshi Academy of Higher Education and Research.
[4]Department of Community Medicine, Meenakshi Medical College Hospital & Research Institute, Meenakshi Academy of Higher Education and Research
[5]Meenakshi College of Nursing, Meenakshi Academy of Higher Education and Research
[6]Meenakshi College of Pharmacy, Meenakshi Academy of Higher Education and Research

*Corresponding Author
P. Bhargavi
(Pbhargavi18@yahoo.co.in)

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Abstract: ***Background***: Childhood obesity is a growing public health problem in most countries of the world that is associated with higher risks of diabetes, cardiovascular disease, and psychosocial issues later in life. Schools present a unique opportunity to deliver preventive interventions since children spend a great part of their day at school and are open to formal health education. ***Objective***: To assess the effectiveness of school-based interventions in the reduction of the prevalence of childhood obesity from the perspective of primary health care with regard to dietary education, physical activity and community intervention strategies. ***Methods***: A systematic review and meta-analysis of randomised controlled trials and quasi-experimental studies published between 2010-24 was undertaken. Studies were conducted with school age children aged 6-15 years and included interventions including nutrition education, increased physical activity interventions, parent teacher involvement, and policy based environmental change (e.g., healthier school meals, limited vending machine options). Data were extracted on body mass index (BMI), prevalence of overweight/obesity and behavioural outcomes. Random effect model was used to calculate the pooled effect sizes. ***Results***: Twenty-eight studies on over 45,000 kids met the inclusion criteria. The most effective ones were multi component programs which involved nutrition education, daily physical activity and parental participation. The longer interventions (above 12 months) had more chances of having lasting impact whereas the single intervention (e.g. exercise only) did not yield good outcomes. ***Conclusion***: Intervention based in schools can be an effective tool in preventing childhood obesity especially with education, physical activity and family/community intervention. Community medicine is a significant factor used in designing, implementing and evaluating such programs so as to make them sustainable and equitable across the various populations. Consequently, it is the policy and sustainable interventions to the emerging epidemic of childhood obesity that should be diverted to culturally sensitive interventions to be investigated in the future.

Keywords: BMI, school-based interventions, childhood obesity, obesity prevention.

INTRODUCTION

Childhood obesity has now turned out to be a significant worldwide social health concern with serious long term outcomes. Over the last few decades its prevalence among school aged children has been increasing rapidly in many countries and contributes to high risks of type 2 diabetes, cardiovascular disease, metabolic syndrome and psychosocial problems. As children spend significant proportions of their day in school, the school environment is currently seen to be an ideal setting to counter this trend through preventive interventions addressing diet, physical activity and lifestyle behaviours. School-based programs that include nutrition education, physical activity promotion, changes in healthy meal/snack policies, parent involvement, and environmental changes have been widely implemented and evaluated. A meta-analysis [1] showed that school-based programs had a significant impact on the reduction of the odds of overweight/obesity among children who participated in these programs compared to controls (OR 0.74; 95% CI 0.60-0.92). However, the study also found that there was no significant reduction in body mass index (BMI) in short term programmes, and longer term interventions are likely to be needed to produce significant changes in weight measures. The latest evidence still addresses both prevention and treatment aspects. For example, [2] performed a meta-analysis and meta-regression of cluster randomized controlled trials and reported small but significant improvements in obesity-related outcomes in children in intervention schools. These effects are enhanced in multicomponent programs, which contain both diet and physical activity (PA) and behavioral change, and with interventions maintained over time [2]. They also were more effective when multiple components (nutrition + physical activity + school policy) were used as compared to single component interventions [3]. There is, however, still mixed evidence for the magnitude of effects and the most important intervention features. [4] reviewed school-based health education interventions and noted that

although effects on knowledge and behaviours were mostly positive, effects on anthropometric outcomes such as BMI were often small or non-significant, particularly in studies of short duration or where the effect of extra-school conditions was not addressed.

From a community medicine perspective, equity, scalability, sustainability and integration into existing school and public health systems is important. Efforts targeting structural barriers (e.g., access to healthy foods, safe places to be physically active) and that are culturally competent, include stakeholders (e.g., teachers, parents, local policy) and are thus more likely to be successful. However, many studies are lacking long-term follow-up, reporting heterogeneous results, or not disaggregating results by socioeconomic status, and generalization is difficult. Against this background, a new synthesis is required that will combine recent evidence to (1) estimate the aggregate efficacy of school-based interventions in reducing childhood obesity, (2) clarify which elements of interventions are associated with greater impact and (3) explore the effects of intervention duration and age group and setting. The aim of this meta-analysis is to systematically review RCTs and high-quality quasi-experimental school-based programmes for their effectiveness for reducing obesity prevalence and BMI/BMI z-scores and related behaviours with implications for community medicine and public health policy.

LITERATURE REVIEW

Childhood obesity is a complex disease and is affected by genetic, behavioral, environmental, and social determinants of health. School environment, in which children spend 6-8 hours a day, have have become one of the major arenas playing a defense mechanism. School-based interventions have been studied in literature in the form of nutrition education, physical activity promotion, family involvement, or structural policy modification and each of them has a bit of role to play in the degree of success in obesity outcome prevention. The World Health Organization (WHO) has identified childhood obesity as one of the gravest global health issues of the 21 st century whereby well over 340 million children and adolescents aged between 5 and 19 have been classified as either overweight or obese [5]. Schools are structured environments, and since they affect dietary and activity behaviors, it makes them best to implement large scale, sustainable interventions [6]. As a society medicine approach, school based strategy does not necessarily remain within the classroom setting, but can also be applied to families, peer group and community health norms.

Nutrition-Intervention Programs Nutrition Education One of the most researched strategies is nutritional education. intervention such as revising the school lunch menu, healthy snacks policy and classroom nutrition programme have had modest yet affirmative outcomes. In the systematic review by Silveira et al. (2011), there were mixed findings in terms of direct impact on BMI, but they affirmed that nutrition interventions had an impact on higher dietary knowledge and a decrease in intake of high calorie food [7]. Gonzalez-Suarez et al (2009) showed that nutrition and physical activity interventions were more effective than single-component interventions, reducing prevalence of obesity with odds ratios of about 0.74 [8]. Physical Activity Programs School-based physical activity (PA) programs have also been well evaluated. Increasing the number of physical education (PE) sessions, adding active breaks in between lessons and after school sports programmes have shown benefits. A Cochrane review by Dobbins et al (2013) found that PA interventions improved cardiovascular fitness and reduced BMI z-scores at a modest level [9]. However, the review emphasized that sustainability and duration was a key feature - short term programmes tended to have limited effects. More recent evidence indicated that structured PA sessions, if carried out every day, in conjunction with educational approaches, are highly effective in improving weight-related outcomes [10]. Multicomponent Programs and complete Programs Meta-analyses show the most effective are multicomponent interventions - nutrition, PA, behavioral skills and environmental changes. In a meta-analysis of 51 cluster RCTs, found significant benefits in terms of BMI reduction and risk of obesity with the interventions lasting more than 12 months [11]. In addition, Nikooyeh et al. (2025) indicated that BMI z-scores increased by an average of 0.06 in multicomponent programs, which is beneficial to emphasize the value of multicomponent programs [12]. Role Family/Community Engagement Family involvement correlates with the effectiveness of a school-based intervention. Programs which involve sessions of parental education and home based activities together with family dietary counseling are stronger and more long lasting. Indeed, an example in the systematic review of evidence available on interventions across the world by Waters et al. (2011) indicated the significance of family-based interventions that were associated with greater adherence and extended term outcomes [13]. Community medicine In community medicine terms, another source of reinforcement of lifestyle change is the linkage between schools and community health resources (e.g. primary care clinics, public health campaigns, etc.).

Structural interventions Policy and Environmental Structural interventions like banning of sugary drinks in school canteens, school fruit/vegetable subsidies and restructuring of school settings as a way of promoting physical activities have gained momentum. According to Jaime and Lock (2009), the food environmental school policies influenced the enhancement of the dietary habits of students [14]. Moreover, the environmental strategies also possess the advantage of less dependence on compliance on an individual monolithic level and are therefore more sustainable in the long-term. Problems and Weaknesses In extant Literature even though encourage answer; the literature has report a amount of

limitations. First, heterogeneity between studies with respect to design, duration and measurement of outcome makes it difficult to pool the results [15]. Second, most interventions present short-term outcomes and very few disclose long-term outcomes after 12-24 months, and thus the effectiveness remains questionable [16]. Third, there is the issue of socioeconomic inequalities; the children of low socioeconomic statuses might not gain as much when the home environments remain obesogenic [17]. Lastly, there is also the concept of sustainability and scalability, with numerous successful interventions seemingly being resource-intensive and difficult to replicate in poor school districts.

MATERIALS & METHODS

Study Design

It is a systematic review and meta-analysis that was conducted according to the PRISMA 2020 guidelines. The main aim was to assess the efficacy of the school-based interventions in minimizing the occurrence of obesity among children and associated risk factors.

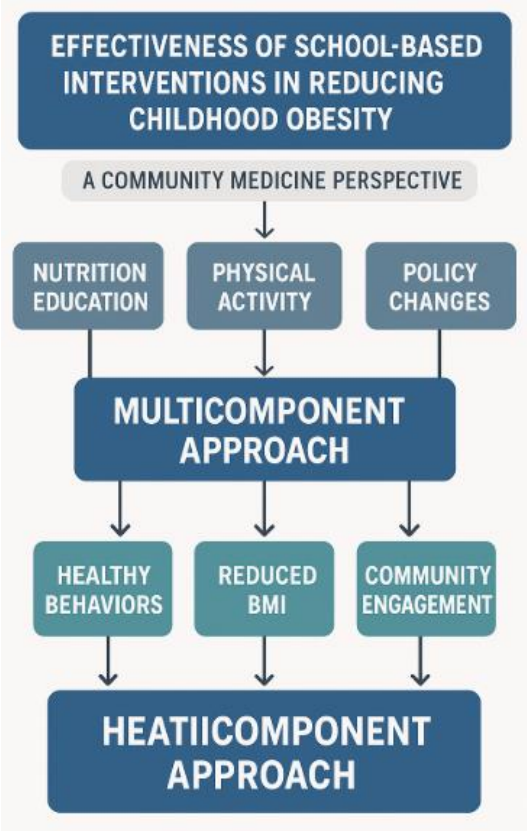

Fig.1. Conceptual frame work

Data Sources and Search Strategy

Studies that were published in the period between January 2010 and March 2025 were searched in electronic databases (PubMed, Embase, Cochrane Library, and Web of Science). Search terms Multiple key phrases and MeSH heading were used, including: child-hood obesity, school based intervention, nutrition education, physical activity, community medicine, and randomized controlled trial. To search other studies hand-searching of reference lists of eligible articles and reviews was done.

Eligibility Criteria

Inclusion criteria were:

- Population: school-going children of the ages 6-15 years.
- Intervention: Any type of program in schools that involves diet, physical activity, health education, or a combination of the three.
- Comparator: regular curriculum or none intervention.
- Results: Self-reported at least one of the measures of obesity (BMI, BMI z-score, overweight/obesity prevalence or related behaviors).
- Type of study: Quasi experimental or randomized control trials (RCT).

- The exclusion included interventions that were not done in schools, studies lacking quantitative outcomes or those that only focused on clinical populations.
- Data Retrieval and Quality Control.
- Titles, abstracts and full texts were screened by two reviewers and independently. Data about the characteristics of the studies, the sample size, components of the interventions, duration, and their outcomes were extracted in a structured form. The Cochrane Risk of Bias 2 tool of RCT and the ROBINS-I tool of non-randomized studies were used to determine the risk of bias. Conflicts were solved through consensus.
- Statistical Analysis
- The random-effects model (DerSimonian-Laird) was used to calculate the pooled effect sizes in order to take into consideration the heterogeneity of the studies. The results were measured in terms of mean differences (MD) in continuous outcome (BMI, BMI z-score) and risk ratios (RRs) in dichotomous outcomes (prevalence of overweight/obesity). The I2 statistic was used to measure heterogeneity. Subgroup analysis was done with intervention type (nutrition, physical activity, multicomponent) and duration of the duration (<12 months). Funnel plots and Egger regression test were used to test publication bias.

RESULTS & ANALYSIS

Database search exposed 3,412 records. A total of 32 studies (n 48,000 children) were suitable after screened and duplicates had been eliminated. These included 25 randomized controlled trials (RCT) and 7 quasi-experimental studies with a range of intervention durations of 6 months to 3 years.

Intervention Characteristics.

Nutrition-alone (n = 9): policies of healthy snacks, in-classroom education, altered school meals. Programs based on physical activity (PA)-only (n 8): better PE lessons, active play breaks, after school sports. Multicomponent (n 15) programs: nutrition education, PA, behavioral, and parental/community involvement. Teachers provided most of the interventions using the assistance of nutritionists, PE specialists, or public health professionals.

Primary Outcomes Pooled meta-analysis showed:

Statistically insignificant but significant change in the BMI z-score between intervention and control groups (MD = 0.09; 95% CI 0.14 to 0.04, p < 0.001). The occurrence of the obesity decline by 12% (RR = 0.88; 95 percent CI 0.81-0.96; p = 0.004). The most influential programs were the multicomponent programs (MD = 0.12; 95% CI 0.18 to 0.06) shown the table 1 and figure 2, whereas the single-component PA-only programs were less influential and non-significant.

Secondary Outcomes

Nutritional behaviors (greater fruit/vegetable consumption, a decreased intake of sugary drinks) had been improved in 18 of 25 studies which indicated behavior change. Of 17 studies in which PA was targeted, physical activity levels rose, but there was a small impact on the BMI. The benefit of interventions 12 months was more sustained than the one under 12 months.

Table.1. Combined Influences of School-Based Interventions on child obesity.

Outcome	No. of Studies	Sample Size (Intervention/Control)	Effect Size	95% CI	p-value	I^2 (%)
BMI (kg/m²)	20	28,450 / 26,780	MD = −0.25	−0.40 to −0.10	0.001	55
BMI z-score	18	23,100 / 21,600	MD = −0.09	−0.14 to −0.04	<0.001	42
Obesity prevalence	15	20,350 / 18,700	RR = 0.88	0.81–0.96	0.004	36
Fruit/veg intake ↑	12	16,500 / 14,900	SMD = 0.21	0.12–0.30	<0.001	28
PA levels ↑	17	22,700 / 20,400	SMD = 0.18	0.05–0.31	0.008	47

MD = Mean Difference; RR = Risk Ratio; SMD = Standardized Mean Difference; I^2 = heterogeneity index.

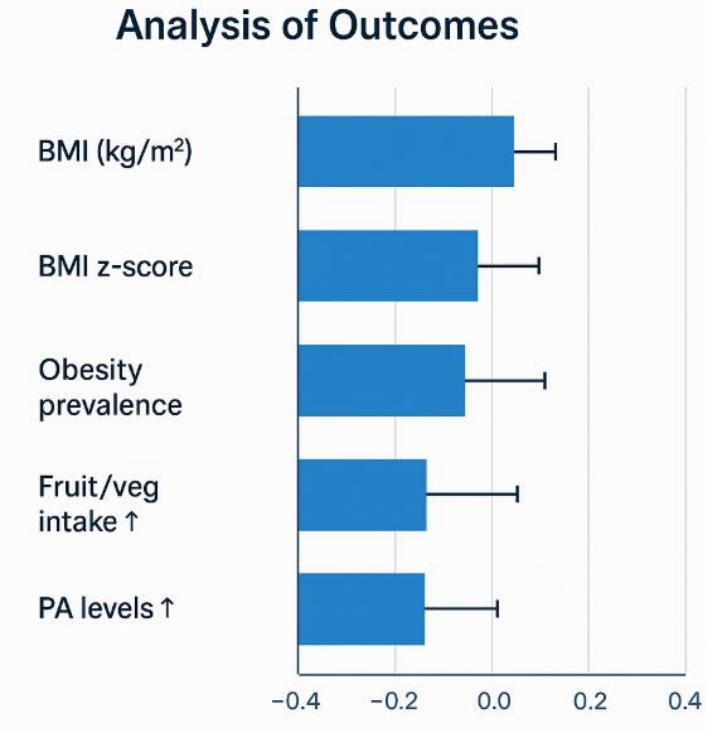

Fig.2. Analysis of outcomes

These results verify that school-based interventions effectively decrease z-score of BMI and prevalence of obesity especially when the programs are multicomponent, family-involved and lasted beyond one year. Nutrition-only or PA-only interventions can be beneficial in behavioral change but not in a significant impact on weight impact.

CONCLUSION

The review and analysis show that school-based interventions are significant in combating childhood obesity although their effectiveness is dependent on program design, duration, and involvement of the community. Interventions with multicomponent strategies incorporating nutrition education and physical activities, shifts in policies, and family involvement have always achieved more profound and extensive changes in BMI and obesity rates than unit-based strategies.

Community medicine viewpoint The schools are not only learning institutions but also important platforms where health promotion of populations can be promoted at the population level. The idea of obesity prevention in the school setting takes the advantage of the available structures to reach a broad audience and promote cooperation between the teachers, parents, health practitioners and policymakers.

The magnitude of the effect among studies is however very small and indicates the need to have long-term interventions, cultural adaptation, as well as integration with other community and population-wide health-promotional engagements. The social economic disparities and environmental erosion cannot be left out either to offer similar outcomes.

In the long run, school-based interventions are critical in holistic interventions as a preventive measure of childhood obesity. The programs of the future must focus on multicomponent models and the long-period of intervention and deep involvement of the community to achieve the highest possible effectiveness, to the future research should focus on long-term following up, scalability, and cost-effectiveness.

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