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Effects of a School-Based Multicomponent Intervention on the Behavior and Anthropometry of Overweight and Obese Children Aged 10-13 Years-a Randomized Control Trial

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Abstract

Obesity is a growing concern in developing countries and is associated with significant mortality and morbidity in childhood. It is attributed to an interplay of environmental and genetic factors. There is a notable difficulty in addressing the various dimensions of managing obesity and hence a combination of interventions incorporating physical activity, education on healthy lifestyle and family involvement becomes a necessity. We aimed to evaluate the effects of a school-based multicomponent intervention (integrating health education, yoga, and parental involvement) on the anthropometric measures and healthy lifestyle behavior of obese and overweight children aged 10-13 years in Puducherry, India. The study included 120 overweight and obese children aged 10-13 years, in two randomly selected urban schools. The children were then randomized to intervention (60) and control (60) groups. The intervention group received health education classes, Yoga classes by certified yoga trainers and parental counseling for 3 months. The control group received routine counseling. Anthropometric measures such as body mass index (BMI), waist-to-hip ratio (WHR), and healthy lifestyle scoring in three domains (nutrition, physical activity levels, and screen time) were assessed pre- and post-intervention for both groups after 3 months. The intervention group showed significant reduction in BMI ($p=0.017$), WHR ($p=0.003$), and improvement in behavior scores of nutrition ($p<0.001$), physical activity ($p<0.001$), and reduced screen time ($p<0.001$) at 3 months post-intervention. No significant changes were observed in the control group on follow-up after 3 months. Thus, we conclude that a school-based multi-faceted intervention is an effective program in combating childhood obesity. We recommend long-term follow-up studies on these interventions to discern the sustainable results of such interventions.

Keywords: Body mass index, child, health education, pediatric obesity, yoga

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Introduction

Childhood obesity has emerged as a silent epidemic in India and poses significant health risks to the nation's younger population. It is a growing concern necessitating a comprehensive understanding of its prevalence and impact. As per the World Health organization (WHO), around 390 million children in the age group of 5-18 years were overweight in 2022[1]. Overweight and obesity in childhood occur due to interaction between genetic, behavioral, and environmental factors. Of particular mention include excess calorie intake, especially unhealthy eating behavior and sedentary lifestyle among Indian children. Overweight and obese young children are at an increased risk of developing non-communicable diseases such as insulin resistance, increased blood pressure, deranged lipid profile, obstructive sleep apnea, and various cancers, which can track into adulthood[2]. Additionally, obesity in children and adolescents can lead to liver diseases, early puberty onset, reduced quality of life, psychiatric disorders, asthma, and other respiratory problems[2]. Efforts to combat childhood obesity have been multifaceted, involving policies aimed at promoting healthier environments in schools, homes, and communities. These include initiatives to improve school nutrition, increase physical activity opportunities, and regulate the marketing of unhealthy foods to children. Despite these efforts, challenges persist in addressing childhood obesity comprehensively. The complex interplay of factors contributing to obesity demands holistic interventions involving all levels of childcare. There is a pressing need to promote a healthy lifestyle early and create supportive environments where children can thrive physically and emotionally. Several international studies have focused on varying combinations of behavioral, nutritional, physical activity, and parental interventions on parameters such as body mass index (BMI), waist-to-hip ratio (WHR), eating habits and physical activity[3-5]. A comprehensive strategy that is multilevel, as well as multicomponent, addressing a wide range of issues is a necessity in India. In this setting, we aimed to study the effects of a school-based multicomponent intervention on the anthropometric profile and healthy lifestyle behavior of obese and overweight children aged 10-13 years.

Highlights

- This study examined the effects of a school-based multicomponent intervention encompassing yoga, nutritional education and parental involvement on anthropometry and behavior of children aged 10-13 years with overweight and obesity.
- There was a significant reduction in body mass index (BMI) and waist-to-hip ratio (WHR) in the intervention group at 3 months post-intervention.
- There was also a significant improvement in behavioral scores in the areas of nutrition, physical activity, and screen use in the intervention group at 3 months post-intervention.
- There was no significant change in BMI, WHR and in behavioral scores in the areas of nutrition, physical activity, and screen time in the control group at 3 months follow-up.
- Thus, this study signifies the importance of a multicomponent strategy in managing children with obesity.

Material and Method

Design and Setting

This was an open-label, school based, randomized control trial conducted over a period of 12 months. The study commenced after the Mahatma Gandhi Medical College and Research Institute Institutional Human Ethics Committee approval and was registered in the Clinical Trials Registry-India (CTRI/2024/07/070695).

Participants

All children aged 10-13 years, with obesity and overweightness (based on the Indian Academy of Pediatrics (IAP) definition)[6], attending urban, private, co-education schools were eligible to participate in the study. Those children with chronic illnesses, dysmorphism, and physical disabilities and those not willing to participate were excluded. Pubertal status assessment was not included in our study protocol, which represents a limitation given the age group studied (10-13 years).

Sample Size Calculation

The sample size was calculated using the formula below, based on observations from a previous RCT[7],

$$n = \frac{2\sigma^2(Z_{1-\beta} + Z_{1-\alpha/2})^2}{(\mu_1 - \mu_2)^2}$$

Mean and standard deviation (SD) of group 1=22.82 and 1.27, mean and SD of group 2= 23.79 and 1.15, with confidence level of 99%, power of 90%. On applying the formula, n was more than or equal to 47. Adding an attrition of 15%, the sample size in each group was rounded to 60.

Sampling

All the urban private, co-education schools in Puducherry (who do not have yoga classes) were listed down by the investigator in alphabetical order, and amongst these schools two schools were chosen randomly, by lottery method. After getting informed written consent from the concerned school principals, the allocation of these 2 schools to study and control group was done randomly by lottery method. Two chits named study group and control group were put inside a box and the headmistress of one school was asked to pick up a chit and the group allocation was done (study group school and control group school).

Selection of Children

All the children in all the sections in the sixth to ninth class (10-13 years of age) of both the schools were screened for overweight and obesity. From the children screened in both the schools, boys and girls were listed separately. Children were selected in both study and control group by simple random sampling by computer-generated random numbers. Thus, the study group consisted of 60 children and the control group had 60 children. Each group had 30 boys and 30 girls. After receiving informed consent from their school principal and also from their parent and written assent from the student, a baseline data was collected. They then filled a knowledge, attitude, and practices (KAP) questionnaire on the healthy lifestyle behavior. They were subjected to anthropometric measurements such as weight, height, waist, and hip circumference. BMI was calculated by the formula, BMI=weight in kg/(height in m)^2. The BMI was plotted on IAP BMI charts. Based on revised IAP guidelines, overweight and obesity was defined by an adult cut-off of 23 and 27 respectively[6]. Then the study group was subjected to a multicomponent intervention for a period of 3 months, after which the outcome measures were assessed again. The control group was given routine advice for weight reduction (advice on diet and physical activity, as per IAP guidelines)[6] for 15 minutes, at the beginning, and then they were followed up after 3 months. Post-intervention, assessment of behavioral and anthropometric measures in both the groups was done at 3 months.

Primary Outcome Measures

Anthropometric Measurements

The height, weight, waist circumference, and hip circumference were measured by the principal investigator. The following indices were computed: BMI, WHR and BMI Z-scores. BMI Z-scores were calculated using WHO Anthro Plus software based on WHO 2007 growth references (https://cran.microsoft.com/snapshot/2022-01-01/web/packages/anthroplus/index.html). Height and weight were measured to the nearest 0.1 cm and 0.1 kg respectively. Height was measured using a stadiometer (Cambia India, New Delhi, India) and weight was measured using an electronic weighing machine (Omron HN-289-EBK model, Haryana, India). Waist and hip circumference were measured using a non-stretchable inch tape. The same instruments were used for all study participants. The waist circumference was measured midway between the lowest rib and the iliac crest, in mid-expiration and hip circumference was measured at thewidest part of the hip (midway between the greater trochanter and lower buttock level).

Healthy Lifestyle Behavior

A KAP questionnaire were designed to assess healthy lifestyle behavior. This questionnaire included 3 areas, namely: Nutrition, physical activity and media use.

1.Nutrition related KAP - This included frequency of consumption of healthy and unhealthy food, 24-hour diet recall chart was obtained, total calorie intake per day, and nutrition knowledge was assessed. A cup measuring 250ml was shown to the student to estimate the amount of food consumed.

2. Physical activity KAP - This section included type and duration of physical activity per day, and knowledge on physical activity types.

3.Screen use KAP - This section included screen time per day, types of devices at home, and knowledge on adverse effects of excess screen time.

The questionnaire was pre-tested and internally validated before being used for data collection. Scoring of behavior was done. There were totally 23 questions, with a score of 0-4 for each question (total score: 0-92). Nutrition, physical activity and screen time domains had 11, 7 and 5 questions respectively, with a maximum score of 44, 28, 20 respectively in each domain. For knowledge score, each correct response was given a score of 4 and wrong response was scored 0. For attitude and practice scoring, a five-point scale was given with a score ranging from 0-4 (A=0, B=1, C=2, D=3, E=4). Higher scores indicated better lifestyle behavior. The content was validated by giving the questionnaire to 8 experts based on their experience and clinical expertise. There was 100% agreement on the appropriateness and relevance of the tool. To ascertain reliability, the questionnaire was administered to 15 children. Test retest was done and reliability was established with a reliability coefficient of 0.91 (pearson product moment correlation).

Multicomponent Intervention

A multicomponent intervention was given to the study group for a period of 3 months, comprising of nutritional and lifestyle education, yoga classes, and parental involvement.

1. Nutritional and Lifestyle Education

This intervention was based on the Dietary Guidelines for Indians[8]. The children were given nutritional and lifestyle education for 3 months. They were given one lecture per month, which lasted a 45-minutes session based on the following areas: The basics of food groups, importance of each food group for health, the difference between complex and simple carbohydrates, the concept of empty calories and its sources, the importance of fiber in the diet, promotion of physical activity, and adverse effects of screen time, the importance of adapting these measures as a lifestyle. The lectures were conducted as direct classes by the investigator and certified nutritionists. There was a group discussion at the end of 3 months. Thus, there were a total of 3 lectures and 1 group discussion.

2. Yoga

Yoga classes were given, three times a week, distributed on alternate days (monday, wednesday and friday). Each session lasted for 30 minutes, conducted by a certified yoga trainer and comprised of the following order (each step for 5 minutes):

- Full body warm up
- Surya Namaskara
- Twisting asanas-Trikonasana, vakrasana, ardha matsyendriyasana, parivritta parsvakonasana
- Lying asanas-sarvangasana, bhujangasana, dhanurasana, navasana, naukasana, sethubandhasana

• Abdominal exercises-paschimuttanasana, pavana mukthasana

• Pranayama-kapalabhati, nadishoda pranayama, bramari pranayama

3. Parental Involvement

Parents of children in the intervention group were counseled for 10 minutes telephonically every month on healthy lifestyle practices. They were also provided with an educational booklet at the beginning of the intervention. They were enquired about their child's eating behavior, screen time and physical activity at home at every phone call.

Results

Baseline Characteristics

The study included 60 children each in the study and control group respectively. Both groups had 30 boys and 30 girls. The recruitment and conduct of the study are shown in **Figure 1**. The anthropometric and behavioral profiles of the children in the study and control group at the beginning of the study are depicted in **Table 1**. The behavioral scores, mean age and weight were comparable between both the groups. The BMI and WHR were higher in the control group as compared to study group. The mean height of study group was found to be higher than the control group.

Outcome Analysis

After 3 months following the intervention, the study group showed a significant decrease in BMI and WHR, along with an increase in the KAP scores in the three areas namely, nutrition, physical activity and screen use (**Table 2**). Thus, the intervention was effective in improving the healthy lifestyle behavior of the children in the study group. However, the mean weight did not change significantly. Amongst the children in the study group, the changes in the behavioral scores were consistently showing an increase in boys as well as girls (**Table 3**). But the BMI and WHR showed a significant increase in boys as compared to girls. This signifies the gender difference in the anthropometric parameters with boys improving better than girls following the intervention.

In the control group, there were no significant changes in the anthropometric parameters and behavioral scores following 3 months after intervention (**Table 2**). Similarly, there was no difference between boys and girls in the outcome parameters compared (**Table 4**). Comparison between the study and control groups post-intervention showed significant improvement in all three KAP scores in the study group as compared to control group (**Table 2**). However, the BMI and WHR of control group continued to be higher than the study group pre- and post-intervention (**Table 2**).

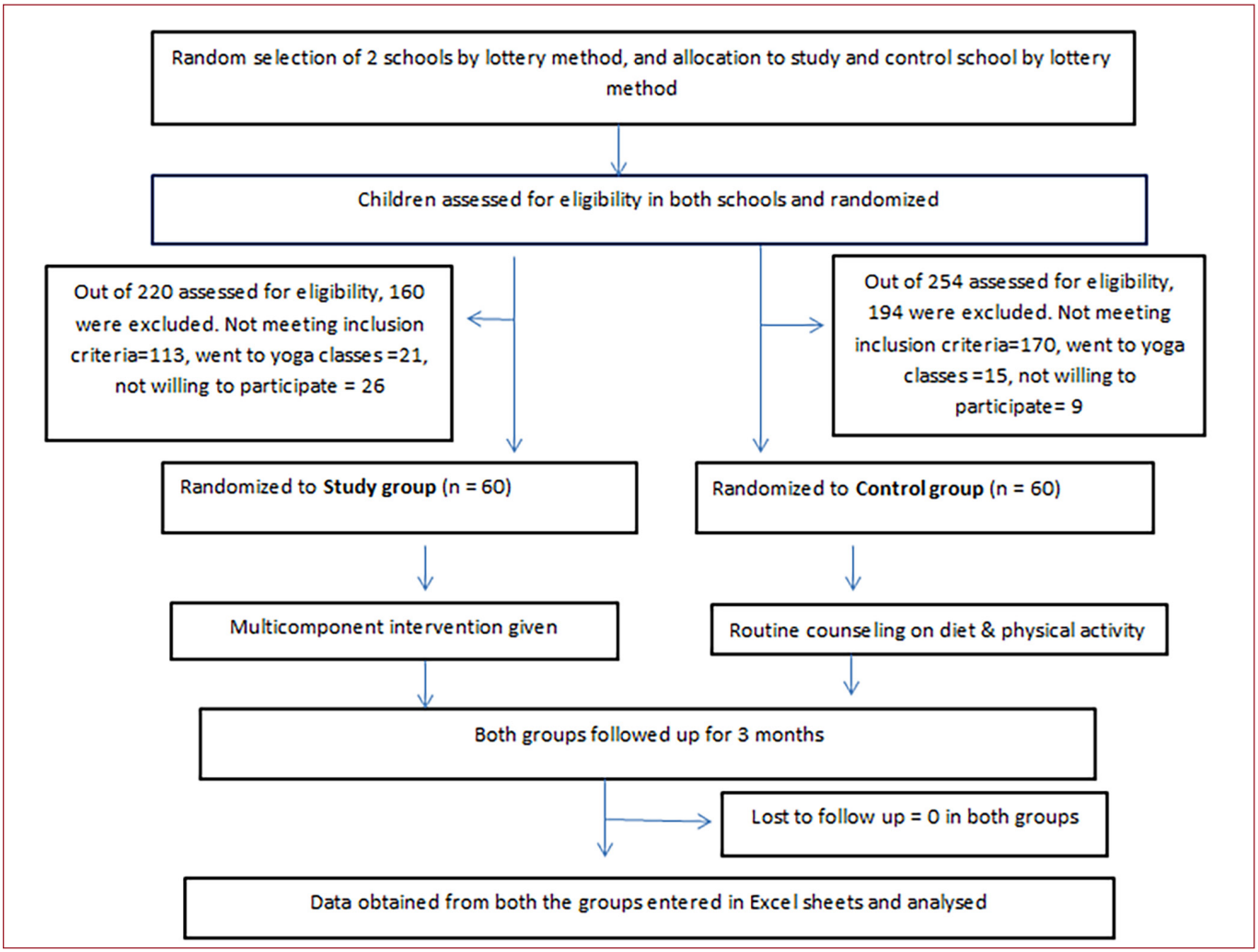

Figure 1. Flow of events in the study

Table 1.
Baseline characteristics of study group & control group

Variable	Study group n=60	Control group n=60	p-value[a]
Age in years, mean (SD)	12.80 (1.20)	12.53 (1.61)	0.614
Males, n (%)	30 (50)	30 (50)	-
Weight in kg, mean (SD)	61.93 (10.06)	60.31 (5.80)	0.284
Height in cm, mean (SD)	159.54 (7.54)	152.16 (7.19)	<0.001
Waist-hip ratio, mean (SD)	0.82 (0.05)	0.89 (0.05)	<0.001
BMI, mean (SD)	24.31 (3.48)	26.02 (1.39)	<0.001
Nutritional KAP score, mean (SD)	23.70 (3.63)	24.62 (3.96)	0.189
Physical activity KAP score, mean (SD)	13.38 (4.88)	13.08 (3.10)	0.689
Screen use KAP score, mean (SD)	10.28 (3.93)	9.40 (3.02)	0.171

[a]; Independent t-test was used, SD; Standard deviation, KAP; Knowledge, attitude, and practices, BMI; Body mass index

Table 2.
Comparison of outcome variables pre-post-intervention, within and between study and control groups

Variable	Study group (n=60)			Control group (n=60)			Post-Intervention comparison between study and control group
	Pre-intervention	Post-intervention	p-value[b]	Pre-intervention	Post-intervention	p-value[c]	p-value[d]
Weight (kg)	61.93 (10.06)	61.90 (9.91)	0.784	60.31 (5.80)	60.60 (5.95)	0.037	0.385
BMI	24.31 (3.48)	24.17 (3.44)	0.017	26.02 (1.39)	26.02 (1.56)	0.957	0.0002
BMI Z-score	2.31 (0.42)	2.28 (0.41)	0.015	2.52 (0.38)	2.53 (0.39)	0.945	0.0009
WHR	0.82 (0.05)	0.81 (0.04)	0.003	0.89 (0.05)	0.89 (0.05)	0.083	0.0001
Nutritional KAP score	23.70 (3.63)	26.45 (3.59)	<0.001	24.61 (3.96)	24.75 (3.41)	0.568	0.0089
Physical activity KAP score	13.38 (4.88)	17.43 (4.76)	<0.001	13.08 (3.10)	13.38 (2.82)	0.293	0.0001
Screen use KAP score	10.28 (3.93)	12.91 (3.44)	<0.001	9.40 (3.02)	9.80 (3.39)	0.172	0.0001

[b,c]; Paired t-test was used, [d]; Independent t-test was used, values are presented as mean (standard deviation), BMI; Body mass index, WHR; Waist-to-hip ratio, KAP; Knowledge, attitude, and practices

Table 3.
Gender-specific comparison of outcome variables pre-post-intervention in study group (n=60)

Variable	Boys (n=30)			Girls (n=30)		
	Pre-intervention	Post-intervention	p-value[e]	Pre-intervention	Post-intervention	p-value[f]
Weight (kg)	59.57 (6.82)	59.53 (6.61)	0.762	64.30 (12.21)	63.63 (11.92)	0.124
BMI	24.77 (2.48)	24.59 (2.46)	0.008	23.87 (3.26)	23.60 (3.31)	0.05
BMI Z-score	2.35 (0.39)	2.31 (0.38)	0.007	2.27 (0.45)	2.25 (0.44)	0.06
WHR	0.81 (0.05)	0.80 (0.05)	0.01	0.84 (0.04)	0.84 (0.04)	0.05
Nutritional KAP score	23.75 (3.45)	26.45 (2.96)	<0.001	23.50 (3.55)	25.26 (3.19)	<0.001
Physical activity KAP score	11.86 (3.52)	15.03 (3.42)	<0.001	15.10 (4.95)	18.17 (4.45)	<0.001
Screen use KAP score	9.68 (4.15)	12.65 (4.24)	<0.001	10.23 (3.97)	13.26 (3.06)	<0.001

[e,f]; Paired t-test was used, values are presented as mean (standard deviation), BMI; Body mass index, WHR; Waist-to-hip ratio, KAP; Knowledge, attitude, and practices

Discussion

The prevalence of childhood obesity is on the rise in India, which is on par with the global trends.[9] It becomes a necessity to devise effective interventions for the same. Overweight and obesity in young people are attributable to a combination of factors such as genetics, nutritional, metabolic, behavioral, environmental, and socioeconomic influences. This study investigated the effects of a school-based multifaceted intervention on the anthropometry and healthy lifestyle behavior of obese and overweight children aged 10-13 years. The findings revealed a significant decrease in BMI (p=0.017) and WHR (p=0.003) in the study group at 3 months post-intervention. The study group also revealed a significant increase in the scores in the KAP areas of nutrition, physical activity, and screen use. There was no significant change in BMI, WHR, or KAP scores of nutrition, physical activity, and screen use in the control

Table 4.
Gender-specific comparison of outcome variables pre- & post-intervention in control group

Control group (n=60)						
Variable	Boys (n=30)			Girls (n=30)		
	Pre-intervention	Post-intervention	p-value[g]	Pre-intervention	Post-intervention	p-value[h]
Weight (kg)	60.61 (5.88)	60.94 (5.73)	0.035	59.65 (6.45)	59.85 (6.36)	0.164
BMI	26.17 (1.37)	26.12 (1.32)	0.82	26.06 (1.48)	25.94 (1.38)	0.275
BMI Z-score	2.54 (0.36)	2.53 (0.35)	0.81	2.50 (0.40)	2.48 (0.38)	0.268
WHR	0.89 (0.04)	0.89 (0.04)	0.79	0.88 (0.04)	0.88 (0.04)	1.00
Nutritional KAP score	24.85 (4.17)	24.91 (3.82)	0.654	26.83 (3.38)	26.74 (3.20)	0.475
Physical activity KAP score	13.15 (2.96)	13.38 (3.03)	0.641	13.11 (3.03)	13.22 (3.29)	0.758
Screen use KAP score	9.40 (2.96)	9.71 (3.11)	0.234	9.80 (3.03)	9.91 (3.04)	0.422

[g,h]; Paired t-test was used, values are presented as mean (standard deviation), BMI; Body mass index, WHR; Waist-to-hip ratio, KAP; Knowledge, attitude, and practices

group on 3 months follow-up. These results project the positive impact of the school-based intervention on children with obesity and overweightness.

In alignment with our study results, a study done in India found that a multicomponent intervention comprising of increased physical activity, nutritional education, and parental involvement effectively reduced BMI and fat percentage, and improved lifestyle practices score at 6 months of follow-up in the study group[10]. Another study consisting of 487 adolescents in the age group of 11-15 years also showed a significant decrease in BMI and WHR after a program that included educational tools and changes in the school[11]. Similar such healthy effects have been proved in other school-based studies[12-14]. Thus, we find combining different strategies such as physical activity, educational reinforcement, parental and school involvement is very effective in reducing BMI. Yoga is the physical activity intervention chosen in our study as it is common in Indian setting. A recent systematic review of nine studies found yoga has a little but meaningful effect on weight loss in children[15]. Also, Jain et al found that in a randomised controlled intervention, yoga combined with dietary modification and lifestyle counselling, was useful in reducing BMI and promoting healthy eating[16].

We found in our study that the nutritional score significantly increased following the intervention. A multi-level community based randomized intervention showed that parental involvement (parent monitoring) was effective in increasing the consumption of fruits and vegetables in obese children[17]. But the study found no change in the BMI of these children[17]. In line with our study results, another quasi-experimental study by Prelip et al.[18] found that a multicomponent intervention improved the knowledge and attitude on healthy eating in obese children. However, the study also found that the intervention did not increase the actual consumption of fruit and vegetables, thus pointing to the need of new strategies in the area of school/home food environment[18]. Our study found that a school-based intervention improved the KAP scores of physical activity. A 70% reduction in sedentary time (which included watching TV, video games, and phone) was observed in a school-based intervention by Cong et al.[19]. Similarly, a parent-related quasi experimental study found the benefits of reducing screen time in children following the change in specific parenting practices[20].

In contrast to our study, an Indian study which was a five-year multicomponent intervention combining education, yoga, with involvement of teachers and families, found no significant change in BMI[21]. This study had no control group which could be a possible limitation[21]. Accordingly, no significant change in BMI was observed in a cluster randomized controlled trial of an intervention targeting education and teacher-parent dyad involvement[22]. However, the intervention was fruitful in improving the healthy eating behavior[22]. So, we find conflicting results with school-based interventions comprising education and family involvement. This could be because of the different study methods, follow-up times, and cultural backgrounds in these studies. These contrasting findings imply the need for further studies with uniform interventional methods and larger sample sizes.

This kind of multicomponent involving the school and family is more feasible in the Indian setting which we find as a strength of our study. Further we have done randomisation at two levels (both selection of schools and selection of children were randomised) which adds more validity to the results. A notable limitation of our study was the significant baseline differences in BMI and WHR between the study and control groups, despite randomization. While this could potentially influence the interpretation of results, the significant within-group changes observed in the intervention group suggest the effectiveness of the multicomponent intervention. Future studies should employ stratified randomization to ensure better baseline comparability.

As highlighted by Kurtoğlu et al.[23]., BMI has limitations in accurately reflecting body composition and fat distribution. While BMI is the primary outcome measured, it is a measure of general adiposity and does not give information on body fat distribution, which is related to cardiovascular disease risks in children as well as in adults. Future studies should incorporate more precise measures of body composition such as bioelectrical impedance analysis to better evaluate intervention effects on body fat percentage and distribution. It is important to note that the follow-up duration in our study was relatively short (3 months), and long-term follow-up is necessary to determine if these positive changes are sustained over time. The lack of pubertal status assessment is another limitation, as pubertal stage can

significantly influence anthropometric measurements and their changes over time. A key limitation of our study design is the inability to determine the individual effectiveness of each intervention component (yoga, nutritional education, and parental involvement). Henceforth we suggest that studies should employ a factorial design with separate intervention arms to evaluate the independent and combined effects of these components.

Conclusion

In conclusion, this study provides valuable evidence supporting the effectiveness of a school-based, multicomponent intervention in addressing childhood obesity in areas such as reduction of BMI, WHR, and improvement in healthy lifestyle behavior. These findings are useful in the short-term period. Howsoever, we suggest future studies which delve into the long-term effects of such interventions and also studies comparing individual strategies with multi-faceted ones.

Ethics

Ethical Approval: The study commenced after the Mahatma Gandhi Medical College and Research Institute Institutional Human Ethics Committee approval and was registered in the Clinical Trials Registry-India (CTRI/2024/07/070695).

Informed Consent: After receiving informed consent from their school principal and also from their parent and written assent from the student, a baseline data was collected.

Footnotes

Manogna T: Surgical and Medical Practices, Design, Data Collection or Processing, Analysis or Interpretation, Writing; Serane VK: Surgical and Medical Practices, Concept, Data Collection or Processing, Analysis or Interpretation, Writing; Chandramoha A: Surgical and Medical Practices, Design, Analysis or Interpretation, Literature Search, Writing; Bhavanani AB: Surgical and Medical Practices, Concept, Data Collection or Processing, Literature Search, Writing; Palanisamy S: Surgical and Medical Practices, Concept, Analysis or Interpretation, Writing.

Conflict of Interest: The authors declare no conflicts of interest.

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