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Effectiveness of school-based nutrition education on obesity and nutritional status of adolescent girls: a scoping review

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ABSTRACT

School based nutrition education is an effective way to improve nutritional status of adolescent girls through changing their dietary behaviors. This scoping review therefore aimed to summarize the available literature evaluating the effectiveness of school-based nutrition education interventions on anthropometric measures and nutritional status of adolescent girls. A systematic approach following the PRISMA guidelines was adopted to investigate the effects of nutrition education in schools. A search term and an eligibility criterion were applied and 2 databases, i.e., Scopus and PubMed were selected to retrieve the existing literature. After applying inclusion/exclusion criteria, a total of 11 studies and data from 3957 participants were included in this review. School-education intervention was taken as an independent variable to evaluate the effectiveness of the programs. Most of the studies found the beneficial effects of school-based nutrition programs to reduce obesity among adolescent girls. However, a few studies (n = 4) did not show any significant impact of nutrition education programs to improve nutritional status of this age-group girls. Our review reported the beneficial effect of school health-education programs to reduce obesity in adolescent girls. A holistic approach with more professional training for teachers based on health promotion strategies, inclusion of nutrition education into the curriculum, operative follow-up and evaluations are needed to implement more effective school-based nutrition education programs.

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1. INTRODUCTION

The coexistence of both under nutrition and over nutrition (double burden of malnutrition) is a major public health concern that widely affects the individuals, families, and communities. The adolescence age group in this regard is a transition phase to adulthood that needs special consideration. This is a critical age group not only for rapid growth and development but also challenged by acquisition of new dietary patterns, personal preferences and physical activity [1]. Obesity on the one hand is an underlying risk factor leading to morbidity, while micronutrient deficiencies including iron, vitamin A, zinc, and calcium are contributing to the disability-adjusted life years (DALYs) in adolescent girls. Statistics from South Asia reported that one in 5 girls of age between 5–19 years are underweight and about 20% adolescent girls are reported with moderate

and severe underweight (<-2 SD BMI) [2]. In contrast, around 16.3 to 33.9% of population of age 15–40 years showed a higher prevalence of obesity [3].

Previous studies in this regard have shown the impact of nutrition education programs to reduce weight and change of dietary habits in overweight adolescent girls [4]. Also, the positive impact of school-based programs has been reported to prevent eating disorders in girls during adolescence [5]. It has been observed that nutrition literacy intervention might help to positively influence lifestyles modification and engagement in social and environmental transformation [6]. Equally, different systematic reviews evaluated the effect of nutrition education interventions leading to healthy food consumption behaviors in adolescents [7]. However, a few studies showed the contrary results with no effects of nutrition education programs on nutritional status, eating patterns and to reduce the weight of adolescent girls [8].

The health outcomes associated with weight gain and obesity appear to increase the risk of chronic diseases including diabetes, cardiovascular diseases, psychosocial abnormalities and even the risk of cancer [9]. It has been observed that nutrition education focusing on carbohydrate counting helped to reduce glycemic index and improved HbA1C in diabetic patients [10]. Similarly, a nutrition education program of 12 weeks decreases the risk of cardiovascular diseases in African Americans [11]. Following that, a 6-year educational intervention program was completed in Crete to evaluate the change in chronic disease patterns. The results observed a significant improvement in biochemical parameters, total cholesterol levels and anthropometric indicators at the end of this health promotion program [12]. Nevertheless, a limited number of studies focused on the impact of awareness programs to improve the anthropometric measures including body mass index (BMI), height, weight, body fat, and thinness in young girls [7].

Considering that, our scoping review summarizes the available literature evaluating the effectiveness of school-based nutrition education interventions on anthropometric measures and nutritional status of adolescent girls. This scoping review aimed to evaluate the effects of school-based nutrition education interventions on BMI, height, weight, waist circumference (WC), percentage of body fat and other anthropometric variable related to nutritional status. This is the first scoping review that will help to measure the efficacy of school-based nutrition education focusing on adolescent girls. The current review has potential to provide guidelines for future policies at local and global levels related to the public health interventions and school environment to improve the nutritional status of adolescent girls. Further, the study findings will help to plan future studies, bringing together different health promotion strategies on school educational programs. Additionally, it will provide futuristic guidelines to modify the existing curriculum plans and health attitudes at individual, community and global level to achieve utmost determined output from these programs.

2. METHOD

This scoping review evaluated the effectiveness of school-based nutrition education interventions on anthropometric measures and nutritional status of adolescent girls. In this regard, a systematic approach was adopted and two scientific reliable databases, i.e., Scopus and PubMed were selected to retrieve the existing literature. A search term of “nutrition” OR “nutrition education” OR “health education” OR “nutrition counseling” OR “nutrition awareness” OR “nutrition teaching” AND “anthropometric” OR “nutrition assessment” OR “Body Mass index” OR “BMI” OR “body weights” OR “nutritional status” OR “body fat” OR “skin folds thickness” OR “middle upper arm circumference” OR “MUAC” OR “stunting” OR “wasting” OR “malnutrition” AND “schools” AND “adolescent girls” was applied for initial data extraction.

2.1. Inclusion/exclusion criteria

The authors set an eligibility criterion to extract precise, reliable, and accurate information matching the study objectives. Studies were eligible if they met the following criteria: i) school based intervention; ii) participants were aged between 10 to 18 years without considering the country, ethnic group, socioeconomic status; iii) we primarily focused on nutritional status of the adolescents girls by using anthropometric measurements therefore, the study reported at least one related aspect such as, BMI, change in body weight, height, thinness, body fat, skin folds thickness, middle upper arm circumference (MUAC) and WC; iv) school interventions were based on nutrition education programs or interventions, dietary modification, healthy diet, nutritional awareness programs, sessions, workshop and seminars.

Since our focus was to evaluate the effects of nutrition education on nutritional status of adolescent girls, studies which combined multiple interventions such as nutritional education and supplementation and showing their effects as a single variable were excluded. However, if this supplementation program studied the nutrition education intervention as an independent variable was included to show the effectiveness of nutrition education programs.

Adolescent girls with any kind of disability or variables such as eating disorders, dyslipidemia, mental or physical disabilities, diabetes, or anemia were not included [10]. Furthermore, the studies showing the

psychosocial measures in terms of improving nutritional knowledge, self-efficacy, behavioral change, dietary diversity scores without anthropometric analysis were excluded for this scoping review [13]. The study was based on school based nutritional intervention while excluding reproductive health, non-communicable diseases, menstrual cycle awareness, only parents' education interventions, interventions outside the school, food fortification, supplying school lunch and breakfast, nutrition education for prevention or intervention of any viral or chronic disease.

2.2. Data extraction

Two independent reviewers scanned the literature through entering the selected search term and applying inclusion/exclusion criteria. The literature search was conducted on December 15th, 2023 with 20 years temporal restriction (2003-2023) to retrieve more recent, comprehensive, innovative approaches and data to improve nutritional status of adolescent girls. The guidelines from preferred reporting items for systematic reviews and meta-analyses (PRISMA) were ensured during the entire process [14]. We enthralled only English language articles or studies during our literature search catering the massive reader's range and interest. Any type of grey literature was excluded whereas all research studies published in a peer review reliable journal were included in this review.

3. RESULTS

The initial search on PubMed retrieved 200 articles, while Scopus resulted in 203 study records. Initially, a total of 110 articles were selected (PubMed = 38; Scopus = 72) after screening the study titles and selected for abstract screening. Further, 56 abstracts were selected for the next step after removing the duplicate and excluding the irrelevant study objectives. Considering the next stage of assessment, the studies (n = 29) not meeting the defined inclusion/exclusion criteria were excluded. A total of 27 articles were selected for full text pursual and finally 11 articles were then included fulfilling the study aims and objectives as shown in Figure 1. All relevant information, such as study year, country, study type, objective, participants characteristics, intervention details, study duration, studied variables, results, and conclusion were summarized in Table 1 (see Appendix) through extraction. Any discrepancies were resolved by the consensus of the reviewers.

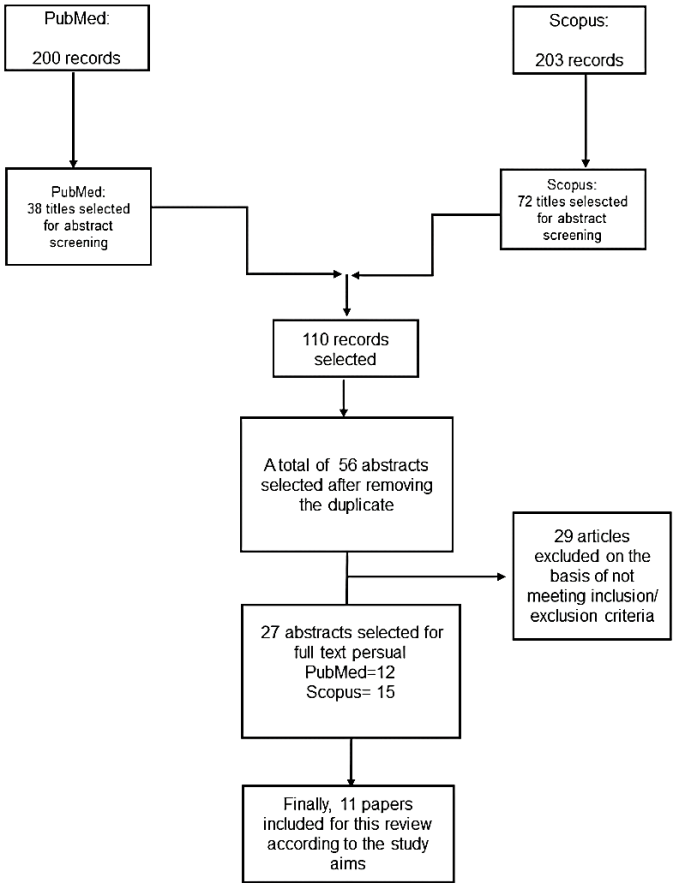

Figure 1. Flow chart of screening process

- Effectiveness of school-based nutrition education interventions on anthropometric measures

A total of 11 studies were included to summarize the effects of school-based nutrition education interventions on anthropometric measures and nutritional status of adolescent girls. A total of 5 studies focused on obesity prevention among adolescent girls through implementing nutritional awareness programs. A study from Iran enrolled 172 adolescent girls and delivered nutrition education for 7 months to find out the changes in BMI, WC, and dietary intake. The study findings seen significant effects of nutrition education in reducing BMI and WC before intervention (BMI = 29.2±3.9; WC = 89.6±2.9) to after intervention (BMI = 28.5±4.3; WC = 86.5±9.8) [15]. Another study from Iran evaluated the effectiveness of nutritional education based on health belief model on overweight and at-risk-of-overweight adolescent girls and found a decrease in BMI even after 2 and 3 months of intervention [16]. Previously, in 2013, the effect of 24-month school-based obesity prevention program reported a change in percentage of body fat among adolescent girls after intervention [Body fat = -1.96(-3.02, -0.89)] [17]. On the same lines, Sarvestani and colleagues assessed the effect of dietary behavior modification on anthropometric indices and eating behavior in obese adolescent girls and found positive significant effects of behavioral modification program on BMI (before intervention = 29.07) reduced to (after interventions = 28.48) [18]. A study from USA evaluated the school-based intervention for obesity prevention and found a decrease in BMI among girls after intervention (27.6 to 26.6) as compared to the control group (25.9 to 26.6) [19].

Adding that, 2 studies reported that school-based nutrition interventions might help to improve the nutritional status of undernourished girls. Such as the effects of a multicomponent school-based intervention program on anthropometric outcomes were investigated by Grydeland and colleagues in Norway. This intervention included multiple intervention efforts to promote a healthy diet and delivered the sessions about awareness of healthy food choices. The results of the study showed that multicomponent school-based intervention programs helped to improve nutritional status with an increase in BMI from (18.0 to 19.0) and WC increased from (62.2 to 65.7) after 20-month nutrition education program [20]. Another experimental study implemented a 6-month nutrition education intervention based on the health belief model in Ethiopia to improve pulse consumption and weight status of 132 adolescent girls and found that nutrition awareness and counseling improved the BMI and height of the girls after intervention [21]. However, 4 studies reported with non-significant or slight positive effects of nutrition education programs on nutritional status among adolescent girls. Recently, Patimah and colleagues determined the efficacy of nutrition awareness focusing on MUAC, BMI and Height-for-Age index (HAZ). The study found that nutrition intervention does not improve the MUAC, BMI and HAZ of the girls as compared to the control group [22]. Another randomized control trial conducted in Ethiopia introduced the pulses-based nutrition education in schools to reduce the proportion of thinness among adolescent girls and did not observe any changes in the reduction of thinness (RR;95%CI, 1.32; 0.60- 2.92) [23]. Likewise, Dunker and Claudino [24] aimed to investigate the effects of New Moves program (NMP) that consist of sports, nutritional support, educational sessions, motivational interviews, collective lunch, parental information materials and counseling. However, the results have not confirmed any significant change in the weight of adolescent girls [24]. The study from Lubans and co-workers introduced a 12-month multicomponent school-based obesity prevention program (NEAT) among adolescent girls and concluded that NEAT program did not help to change BMI in experimental group (BMI = 23.30±4.71) as compared to control group (BMI = 23.37±4.68) [25].

4. DISCUSSION

Our results found that school-based nutrition education programs might help to reduce BMI, WC and percentage of body fat in overweight adolescent girls while no significant effect was observed to improve the height, WC, and thinness indicators among undernourished adolescents' girls. Emphasizing nutrition education in schools appears to create awareness regarding healthy food choices, maintenance of weight, prevention of obesity and to reduce the futuristic risk of communicable and non-communicable diseases [26].

Our findings observed that school based nutritional awareness programs help to control excessive weight gain and obesity prevention in girls. In agreement to our results, a recent study found that school-based exercise and nutrition intervention reduce BMI and body fat in overweight adolescent girls [27]. Similarly, another study found that nutritional and lifestyle interventions in the school environment can change students' behavior changes and obesity prevention in adolescents [28]. Similar to many studies, we used anthropometric measures as a primary variable to provide the best suitable indicator for nutritional status of adolescent girls. Being the frequently used indicator for nutritional status, anthropometric measures might help to prevent biased results investigated by observers, instruments, and informants [29]. In concomitant, BMI and other anthropometric measures can help to provide a thorough portrayal of the effectiveness of school-based nutrition programs [30]. BMI is the most frequently used predictor to evaluate the effects of school-based nutritional programs [31]. BMI is a standardized assessment method measured as individual weight (kg) divided by his/her

height (m). According to the World Health Organization (WHO) BMI values (> + 1 SD) are considered as overweight while (> + 2 SD) are measured as obesity considering the specific age and gender [32]. Moreover, skin-fold thickness of adolescents is another important predictor to evaluate body fitness. Though we find a limited number of studies in this regard.

Few studies included in this scoping review have reported non-significant effects of health education programs to improve the nutritional status or change in BMI of the girls. Few other studies showed the varied results according to gender differences, age or weight status and ethnicity of the children [20]. In contrast to our findings, a study considering the multiple component health education program found the beneficial effects of nutrition education to improve nutritional status during adolescence [33]. The included studies in our scoping review did not particularly consider socio-economic status that might be considered a major reason for these non-significant effects [30]. Family environment, parents' knowledge, economic status are important parameters, and confounding factors might affect the results outcomes [34]. Such as Bere and colleagues previously found that adolescents living with educated parents have better nutritional status and healthy eating habits as compared to the control group living with less educated parents [35]. Also, many other studies have reported the positive effects of parent's education in improving dietary diversity, intake of fruits and vegetables and nutritional behavior in adolescent children [36]-[38].

In summary, we found that school-based nutritional programs can help to improve the nutritional status of adolescent girls. Since, the classroom activities and education are regularly accentuated on course learning outcomes, traditional curriculum, and formal education. Nutritional education in schools will help to increase nutritional awareness, healthy eating and obesity prevention in adolescent girls. Also, school based nutrition intervention including self-efficacy/perceived control, outcome expectations/attitude, habit, and behavioral intention might help to change dietary habits leading to better nutritional status [39]. A holistic approach with more professional training for teachers based on health promotion strategies, future quantitative and qualitative studies, longer duration of interventions, comprehensive follow-up and evaluations are needed to implement efficient school-based nutrition education programs and health promotion. Further studies and interventional trials will provide futuristic guidelines in order to modify the existing education programs and health attitudes at individual, community, and policy level to achieve determined health outcomes.

This is the first comprehensive scoping review focusing on the efficacy of school-based nutrition education on anthropometric variables including BMI, fat changes, height, weight, MUAC, WC among adolescent girls, however, limited number of studies and lack of enough interventional trials was a limitation while conducting this scoping review. Similarly, most of the included studies provided limited and heterogenous data in terms of intervention, methodology and outcomes. Due to limited number of studies and heterogeneity among the results variables, it was not possible to conduct a meta-analysis and to generalize the results on different populations. We did not include studies with parental involvement, education and awareness in the context of healthy dietary patterns. Also, the level and effects of teacher nutritional awareness were not reviewed. It can be considered another study limitation. More studies with long term interventions are needed to apply a comprehensive approach to modify the existing school-based health programs. In concomitant, large scale nutritional intervention programs on community level both in high- and low-income countries can help to halt double burden of malnutrition.

5. CONCLUSION

Our review reported the beneficial effects of school-based nutrition education to improve health and to reduce obesity in adolescent girls. Since nutritional intervention programs can improve nutritional habits through fun activities and interactive session. School-based nutrition programs can be a vital and cost-effective strategy to increase nutritional awareness, healthy lifestyle, eating behaviors and to address nutritional deficiencies among adolescent girls. The introduction of nutrition education into the study curriculum continues support from teachers, effective parents' education, counseling of the students, introduction of daily physical activity, and provision of fruits and vegetables by school food services might help to acquire wide-ranging health benefits to adolescent girls. Also, nutrition education programs through other platforms such as community engagement, parents' awareness, peers' involvement, healthy messages on social media and web-based education might help to improve outcomes.

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY

The authors confirm that the data supporting the findings of this study are available within the article.

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APPENDIX

Table 1. Effectiveness of school-based nutrition education interventions on body mass index and nutritional status of adolescents girls

Reference/country	Study type and objective	Participants	Intervention	Included variables	Results	Remarks
[22]/ Indonesia	A quasi-experimental design study This study determined the efficacy of school-integrated interventions on nutrition-health knowledge and nutritional status among adolescent girls.	Total (n =342) Intervention group (n = 262) Comparison group (n = 80)	Adolescent girls in the intervention schools were given educational interventions plus supplementation. Also, nutrition-health counseling to adolescent girls by trained primary health care officers using poster media while control groups only received nutrition education. Teachers trained (14 people) by the research team provided four weeks of educational intervention. The delivery of the material was carried out around 40-90 minutes per material, depending on the number of the material taught by the teacher using PowerPoint, Video, and LCD (liquid crystal display).	– Mid Upper Arm Circumference (MUAC) – BMI according to Age (BAZ-score) – Height-for-Age index (HAZ)	Baseline results (Mean±Sd) Intervention group MUAC (cm) = 23.7±3.6 BAZ = - 0.2±1.2 HAZ = -1.56±0.9 Comparison group MUAC (cm) = 23.6±2.8 BAZ = - 0.02±0.9 HAZ = -1.79±0.8 Post intervention results (Mean±Sd) Intervention group MUAC (cm) = 25.3±3.4 BAZ = - 0.1±1.2 HAZ = -1.62±0.8 Comparison group MUAC (cm) = 25.6±3.1 BAZ = 0.01±0.9 HAZ = -1.85±0.8	In conclusion, there was slight (non-significant) difference between school-integrated interventions along with nutrition education than nutritional education alone in improving nutrition-health knowledge and nutritional status among adolescent girls. Also, there was no change in effects when compared with the control group.
[23]/ Northwest Ethiopia	Randomized control trial. The study aimed to observe the effectiveness of pulses-based nutrition education in reducing the proportion of thinness among adolescent girls.	Total (n = 547) 547 Intervention group (n = 269) Control group (n = 278) Age = 15–19 years	The education sessions were delivered over 4 weeks on a 45–60-min session per week basis. Pulses-based nutrition education was used as intervention based on Pender's Health Promotion Model domains, whereas the usual dietary practice of adolescent girls was the comparator.	– Thinness	Effect of pulses-based nutrition education in reducing thinness intervention group vs control group (Adjusted Relative Risk; 95%CI) = 1.32; 0.60,2.92.	This study did not find any significant effects of pulses-based nutrition education in reducing thinness in adolescent girls; however, positive behavior change was observed toward the consumption of pulses-based food among the intervention group.

Table 1. Effectiveness of school-based nutrition education interventions on body mass index and nutritional status of adolescents girls (continued)

Reference/country	Study type and objective	Participants	Intervention	Included variables	Results	Remarks
[21]/Southern Ethopia	A quasi-experimental design study The study evaluated the effect of a 6-month nutrition education based on the health belief model to improve pulse consumption on weight status of adolescent girls in Ethiopia.	Total (n = 132 Intervention group (n = 66) Control group (n= 66) Age = 11–19	Bi-monthly nutrition education sessions for 6 months (a total of 11 sessions) were provided. The intervention group received bi-monthly lessons, recipes and tastings with pulse-based nutrition education, discussions and demonstrations, knowledge, attitude.	– Weight – Height – Thinness	Baseline results (Mean±Sd) Control group Weight (kg) = 45.6±5.5 Height (cm) BAZ = 153.6±4.2 Prevalence of thinness = 12±18.2 Intervention group Weight (kg) = 45.7±3.9 Height (cm) BAZ = 153.4±4.40 Prevalence of thinness = 13±19.7 After intervention (Mean±Sd) Control group Weight (kg) = 45.7±5.4 Height (cm) BAZ = 153.8±4.1 Prevalence of thinness = 13±19.7 Intervention group Weight = 47.8±3.4 Height = 154.5±4.4 Prevalence of thinness = 11±16.7	This study found that nutrition education based on the health belief model increased knowledge, attitude, and nutritional status of adolescent girls. The results showed significant effects to improve BMI and height while reducing the thinness.
[24]/ Brazil	Cluster-randomized controlled trial The study aimed to determine the effects of New Moves program (NMP) among Brazilian adolescent girls.	Total (n = 270) Intervention group (n = 131) Control group (n =139) Age = 12-14 year	Participants received the following interventions. 1. group physical education sessions entitled ‘Be active’ with two one-hour sessions weekly for nine weeks. 2. Interactive group educational sessions with dietitians and psychologists, entitled respectively ‘Be Fueled’ and ‘Be Fabulous’ with one weekly session lasting one hour for eight weeks. 3. Two sessions of individual counseling using motivational interviewing techniques.	– BMI – Weight-Control	Baseline results (Mean±Sd) Control group BMI = 21.8±4.81 Intervention group BMI = 20.88±3.87 Post intervention results (after maintenance period) [BMI (95%CI)] Control group BMI = 22.28 (21.47, 23.1) Intervention group BMI = 21.6 (20.75, 22.45)	The study found that NMP program slightly change the BMI of adolescent girls.

Table 1. Effectiveness of school-based nutrition education interventions on body mass index and nutritional status of adolescents girls (continued)

Reference/country	Study type and objective	Participants	Intervention	Included variables	Results	Remarks
[15]/Iran	Cluster randomized community trial The study evaluated the effects of nutrition education focusing on social cognitive theory to improve dietary habits and to reduce BMI and WCs among overweight and obese girl students.	Total (n = 172) Intervention group (n = 87) Control group (n = 85) Age = 12-16 years	Duration: 7-month The intervention was based on the following components. 1) Practical nutrition workshops and interactive seminars 2) Visiting industrial food companies. To get more familiar and to make a positive attitude for healthy food. 3) Healthy cooking workshops. Targeted on healthy cooking options. 4) Text messages for students and parents to create and maintain healthy nutritional behaviors. 5) Parents' newsletters 6) Calls to students to improve self-efficacy and to support children for healthy diet. 7) Monthly nutritional consulting private sessions	– BMI – WCs – Dietary intake	Baseline Results (Mean±Sd) Control Group BMI = 27.2±2.9 WC = 84.4±6.7 Intervention group BMI = 29.2±3.9 WC = 89.6±2.9 After intervention (Mean±Sd) Control Group BMI = 27.6±2.9 WC = 84.9±6.4 Intervention group BMI= 28.5±4.3 WC = 86.5±9.8	The study showed that nutrition education may help to reduce BMI and WC.
[16]/Iran	An experimental study The study aimed to assess the effectiveness of nutritional education based on health belief model on self-esteem and BMI of overweight and at risk of overweight adolescent girls.	Total (n =140) Intervention group(n=70) Control group (n=70)	Duration: 3 months Education based program was based on a health belief model for improving nutritional status. The six 60-minute sessions were conducted based on health belief model and emphasizing diet to control weight in overweight and at-risk adolescents' girls.	– BMI	Results (Mean±Sd) Control group BMI = 27.11±1.27 2 months after intervention BMI = 27.19±1.55 3 Months after intervention BMI = 27.13±1.56 Intervention group BMI = 27.15±1.21) 2 months after intervention BMI = 26.82 ±1.42 3 Months after intervention BMI = 26.70±1.38	The study found that nutrition education has a preventive and controlling effects on weight and BMI.

Table 1. Effectiveness of school-based nutrition education interventions on body mass index and nutritional status of adolescents girls (continued)

Reference/country	Study type and objective	Participants	Intervention	Included variables	Results	Remarks
[20]/Norway	Cluster randomized trial This study investigated the effects of a multicomponent school-based intervention program on anthropometric outcomes.	Total (n = 1,324) Intervention group (n = 465) Control group (n = 859) Girls (n = 643) Boys (n = 681) Age = 11-year	A 20-month intervention The multilevel approach included collaboration with school principals and teachers, school-health services, and parent committees. Multiple intervention efforts were organized to promote a healthy diet and to increase awareness of healthy choices, to increase participants' physical activity during school hours and leisure time, and to reduce screen-time.	– BMI – BMI-for-age z-score (BMIz) – WC – Waist-to-Height Ratio (WTHR)	Baseline results (girls) (Mean±Sd) Control group BMI = 17.9±2.6 WC (cm) = 63.3±6.5 WTHR = 0.43±0.04 Intervention group BMI = 18.0±2.6 WC (cm) = 62.2±6.2 WTHR = 0.42±0.04 After 20 months intervention (girls) (Mean±range) Control group BMI = 19.2 (19.1 to 19.3) WC (cm) = 66.0 (66.0 to 66.3) WTHR = 0.414 (0.412 to 0.416 Intervention group BMI = 19.0 (18.8 to 19.3) WC = 65.7 (65.3 to 66.1) WTHR = 0.413 (0.416 to 0.421)	This study reported that multicomponent 20-month nutrition education intervention had a beneficial effect on BMI and WC in intervention group.
[17]/Austrailia	Cluster randomized trial The study determined the effect of 24-month school-based obesity prevention program among adolescent girls.	Total (n = 357) Intervention group (n = 178) Control group (n = 179) Age = 13.2±0.5 years	This multicomponent intervention based on social cognitive theory and involved strategies to promote physical activity, reduce sedentary behaviors, and improve dietary outcomes.	– BMI – Percentage body fat	Baseline results (Mean±Sd) Control group BMI = 22.59±4.49 Body fat (%) = 28.31±6.76 Intervention group BMI = 22.70±4.70 Body fat (%) = 29.58±6.54 After 24 months intervention (Mean±Sd) Control group BMI = 24.11±5.07 Body fat (%) = 30.08±6.39 Intervention group BMI = 23.86±4.77 Body fat (%) = 29.25±6.65 (adjusted mean difference; 95%CI) BMI = -0.33 (-0.97, 0.28) Body fat (%) = -1.96(-3.02, -0.89)	The study reported a slight change in percentage body fat among adolescent girls after intervention as compared to control group.

Table 1. Effectiveness of school-based nutrition education interventions on body mass index and nutritional status of adolescents girls (continued)

Reference/country	Study type and objective	Participants	Intervention	Included variables	Results	Remarks
[25]/Australia	Cluster-randomized controlled trial The study determined the effect of a 12-month multicomponent school-based obesity prevention program (NEAT) among adolescent girls.	Total (n = 357) Control group (n = 179) Intervention group (n = 178) Age = 12 – 14 years.	The intervention was based on a group randomized controlled trial with 12- month follow-up. A multicomponent school-based intervention program tailored for adolescent girls including interactive seminars, nutrition workshops, lunch-time physical activity sessions, handbooks and pedometers for self-monitoring, parent newsletters, and text messaging for social support.	– BMI – BMI *z* score – Body fat percentage	Baseline results (Mean±Sd) Intervention Group BMI= 22.70±4.70 BMI *z* score = 0.82±1.12 Body fat (%) = 29.58±6.54 Comparison Group BMI= 22.59±4.49 BMI *z* score = 0.78±1.16 Body fat (%) = 28.31±6.76 Post intervention (Mean±Sd) Group Intervention Group BMI= 23.30±4.71 BMI *z* score = 0.76±1.16 Body fat (%) = 32.72±5.85 Comparison Group BMI= 23.37±4.68 BMI *z* score = 0.81 ±1.17 Body fat (%) = 32.55±5.87	The study reported that NEAT program did not significantly change BMI as compared to control group.
[18]/Iran	A quasi-experimental design study The study assessed the effect of dietary behavior modification on anthropometric indices and eating behavior in obese adolescent girls	Total (n = 60) Intervention group (n = 30) Control group (n = 30) Aged = 11–15 years	The girls participated in a behavior modification program for 16 weeks (6-month intervention program). 4-hour structured sessions for the experimental group were held weekly.	– Weight – BMI – Arm circumferences	Before intervention Control group Weight (kg) = 73.49 BMI (kg/m2) = 29.07 Arm circumferences (cm) = 31.50 Experimental group Weight (kg) = 75.12 BMI (kg/m2) = 29.55 Arm circumferences (cm) = 31.60 After intervention Control group Weight (kg) = 74.11 BMI (kg/m2) = 29.31 Arm circumferences (cm) = 32.00 Experimental group Weight = 72.37 BMI (kg/m2) = 28.48 Arm circumferences (cm) = 29.29	This study reported the positive significant effects of behavioral modification program on anthropometric indices and improving eating behavior in adolescents' girls.
[19]/USA	Randomized controlled trial. This study aimed to evaluate the school-based intervention program for obesity prevention among adolescent girls	Total (n = 201) Intervention group (n = 89) Control group (n = 112) Age (mean±Sd) = 15.4±1.1	8-month follow-up The program included nutrition and social support sessions that were each offered every other week on alternating weeks throughout a 16-week semester. Moreover, physical activity was offered four times a week.	– BMI	Baseline results (Mean±Sd) Control group BMI = 25.9±5.8 Intervention group = 27.6±7.2 Post intervention results Control group BMI = 26.65 Intervention group BMI = 26.64	The study showed a decrease in BMI before and after in the intervention group.

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