Original Article

Limitations of studies on school-based nutrition education interventions for obesity in China: a systematic review and meta-analysis

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Background and Objectives: School-based nutrition education has been widely implemented in recent years to fight the increasing prevalence of childhood obesity in China**. Methods and Study Design:** A comprehensive literature search was performed using six databases to identify studies of school-based nutrition education interventions in China. The methodological quality and the risk of bias of selected literature were evaluated. Stratified analysis was performed to identify whether different methodologies influenced the estimated effect of the intervention. **Results:** Seventeen articles were included in the analysis. Several of the included studies had inadequate intervention duration, inappropriate randomization methods, selection bias, unbalanced baseline characteristics between control and intervention groups, and absent sample size calculation. Overall, the studies showed no significant impact of nutrition education on obesity (OR=0.76; 95% CI=0.55-1.05; p=0.09). This can be compared with an OR of 0.68 for interventions aimed at preventing malnutrition and an OR of 0.49 for interventions aimed at preventing iron-deficiency anemia. When studies with unbalanced baseline characteristics between groups and selection bias in the study subjects were excluded, the impact of nutrition education on obesity was significant (OR=0.73; 95% CI=0.55-0.98; p=0.003). An analysis stratified according to the duration of intervention revealed that the intervention was effective only when it lasted for more than 2 years (OR=0.49, 95% CI=0.42-0.58; p<0.001). **Conclusion:** Studies of school-based nutrition education programs in China have some important limitations that might affect the estimated effectiveness of the intervention.

Key Words: nutrition education, school children, obesity, systemic review, meta-analysis

INTRODUCTION

With recent social and economic development in China, living standards have been greatly improved. However, the nutritional status of Chinese children is of suboptimal due to a lack of knowledge about appropriate nutrition, diet structure,[1] and exercise.[2] Obesity, malnutrition, and iron-deficiency anemia are common amongst Chinese teenagers.[3-5] Imbalanced nutrition status during childhood can hugely diminish a child's quality of life, decrease self-esteem in teenage years,[6] and increase the risk of depressive symptoms.[7] Moreover, obesity is closely linked to chronic and nonreversible diseases such as type II diabetes,[8] hypertension, cardiovascular disease,[9] and musculoskeletal disease,[10] and obesity-related lifestyle behaviors cultivated during childhood perpetuate into adulthood.

In China, nutrition education is achieved by a combination of several educational strategies. Nutrition education is accompanied by environmental support and is designed to facilitate voluntary adoption of food choices and other food- and nutrition-related behaviors that are conducive to health and well-being. Nutrition education can be delivered using various approaches an is supported by individuals, communities, and national policy.[11] The advantages of nutrition education are that it requires small financial investment and delivers big social reward. It plays a significant role in improving the level of nutrition knowledge, changing people's attitude toward nutrition, and establishing proper dietary behaviors in communities and individuals.[12]

Currently, nutrition intervention programs are often delivered through nutrition education in China. Compared with community-based nutrition education, school-based nutrition education has unique advantages such as offering the opportunity for children to interact with the educators delivering the intervention, and has a powerful influence on children's health within a positive school infra-

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structure and physical environment. Policies, curricula, and personnel also play important roles in providing opportunities for frequent interactions amongst students, which increases their familiarity with and use of nutrition-related knowledge.[13] Generally in China, only overweight, moderately obese, severely obese, or pathological obese children enter the clinical sector, and this sector therefore emphasizes treatment rather than prevention and deals with fewer children than school-based nutrition education intervention. However, compared with the 'Ensemble Prévenons l'Obésité Des Enfants' (EPODE, Together Let's Prevent Childhood Obesity) approach,[14] which was large-scale, coordinated, capacity-building approach for communities to implement effective and sustainable strategies to prevent childhood obesity, school-based nutrition education mainly improved the obesogenic environment in schools. Long-term results may be achieved through ongoing support from society as a whole, including parents, schools, and government agencies, which is part of the EPODE approach but not the school-based nutrition education approach.[15]

In this paper, we review the existing literature with regard to school-based nutrition education aimed at preventing obesity in primary school students in China. We implement a quality evaluation and quantitative analysis to explore various issues in study design and methodology and the impact of these issues on the estimated effect of the intervention. We found that the published studies have some important limitations, which results in inconsistency in the evaluation of the effect of the intervention.

METHODS

Literature search strategy

Multiple queries using following key words were performed in PubMed, ISI Web of Knowledge, and Embase: (pupil* or primary school student* or elementary school student* or child* or schoolchild* or primary scholar* or schoolboy* or schoolgirl*) and (nutrition* intervention* or nutrition* prevention* or nutrition* education) and China. An additional search was undertaken in the China Knowledge Resource Integrated Database, Wanfang Database, and Chinese Biomedical Literature Database using the following terms: (ying yang gan yu or ying yang jiao yu or ying yang xuan jiao) and xiao xue sheng. The reference lists and bibliographies of all potentially relevant articles identified by these searches were also searched. To maximize the inclusion of relevant literature, no restrictions were set regarding publication date. The latest publication was at the end of November 2014. Two researchers independently retrieved and extracted the basic information, and then resolved ambiguities through discussions.

Inclusion and exclusion criteria

To better evaluate the effectiveness of school-based interventions for childhood obesity, we compared the effect of these programs to that of school-based nutrition education interventions for childhood malnutrition or iron-deficiency anemia; therefore, we also included studies about school-based nutrition education for childhood malnutrition or iron-deficiency anemia. The primary inclusion criteria were: (1) the nutrition education was delivered via a school-based program at a school in China; (2) the target population for the intervention was primary school students; (3) no medication or auxiliary food was used as part of the intervention; and (4) the aim of the intervention was to reduce obesity, malnutrition, or iron-deficiency anemia. Moderate adjustments were made to the exclusion criteria according to the outcome under study (obesity, malnutrition, or iron-deficiency anemia) (Figure 1). Obesity and malnutrition were defined according to BMI using age-and-gender specific cutoff points developed by the World Health Organization or by country-specific norms. Iron-deficiency anemia was defined as Hb concentration <120 g/L, in accordance with the Diagnosis Criteria for Anemia for boys or girls aged younger than 15 years recommended by the World Health Organization.[16]

Methodological quality and risk of bias

The modified Jadad scale[17] was used to evaluate the validity and quality of randomized trials.[18,19] However, this tool is not supported by empirical evidence,[20,21] and when we calculated the summary scores, it was difficult to justify the weights assigned to different items. The scale does not provide a reliable indication of validity.[22] The risk of bias assessment tool, recommended by the Cochrane Collaboration, is a domain-based evaluation in which critical assessments are made separately for different domains. This can reduce the influence of subjective factors and remedy several drawbacks of the Jadad scale.[23] The Cochrane Handbook draws a distinction between the assessment of methodological quality and of risk of bias.[24] In this study, we used both the modified Jadad scale and the Cochrane risk of bias assessment tool to make a dual evaluation of the methodological quality and the risk of bias of the included literature.

Information extraction

Basic information was extracted from each of the selected studies, including first author, publication year, study area, participants, intervention mode, intervention duration, and outcome measures.

Statistical analysis

Data were analyzed using Reviewer Manager software version 5.1, provided by the Cochrane Collaboration. The Q test was used to test the heterogeneity of studies. The Q test is based on the χ^2 distribution and provides a measure of the sum of the squared difference between the results observed and the results expected in each trial, under the assumption that each trial estimated the same intervention effect. Heterogeneity analysis of the selected literature was performed using either a fixed effects model ($p \geq 0.05$) or a random effects model ($p < 0.05$). We merged the relevant indicators to calculate a pooled OR and its 95% CI.[25] A difference was considered to be significant at the alpha level of $p < 0.05$. We analyzed publication bias using a funnel plot when the included number of papers was no less than ten.[26]

We identified limitations of the study design and methodology for the selected literature, and conducted a meta-analysis for each limitation identified to determine whether or not it influenced the estimated intervention

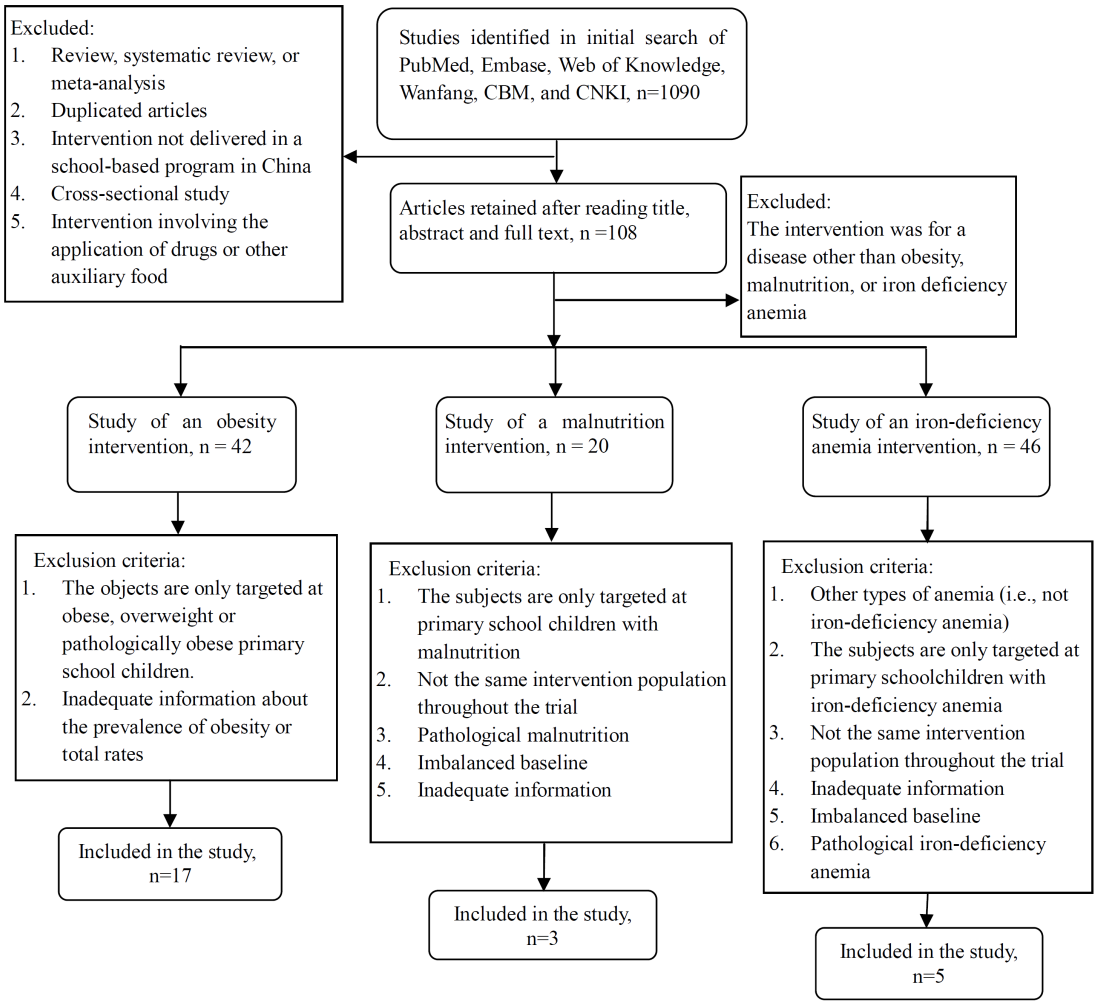

Figure 1. Flow diagram of trials selection. CNKI: China Knowledge Resource Integrated Database; CBM: Chinese Biomedical Literature Database

effect. In addition, we performed a meta-analysis to compare the intervention effect of nutrition education on childhood obesity with the intervention effect of nutrition education on malnutrition and iron-deficiency anemia in schoolchildren in China.

RESULTS

Seventeen[27-43] of the 1090 retrieved studies met the inclusion and exclusion criteria and were included in the analysis (Table 1). Among them, only one study[30] had a pre- and post-test repeated measures design with no control group, and the other 16 studies all had intervention and control groups.

Methodological quality and risk of bias

The modified Jadad Scale was used to evaluate the methods of the 17 included studies (Table 1). The following limitations were identified: absence of randomization, unbalanced baseline characteristics, selection bias, absent sample size calculation, and inadequate education intervention duration (Table 2). The Cochrane risk of bias assessment tool was used to evaluate bias in the eventually included 11 studies after we excluded six studies[27-32] with the defect of group differences at baseline or selection bias (Figure 2).

Baseline characteristics of the study sample

In the 16 studies with a control group, the test of between-group differences at baseline mainly focused on age, gender, and prevalence of obesity. Utilizing the information provided in each article, we performed a statistical comparison of the baseline characteristics of the two groups and found an imbalance between the groups in at least one of these three variables in four studies.[27-29,36] In nine studies,[27,31-33,35,36,39,42,43] there was a similar distribution of age in the intervention and control groups, but seven studies[28,29,34,37,38,40,41] did not provide adequate information to make this comparison for age. Nine studies[27,32-36,39,42,43] compared gender across groups: One[36] reported an imbalance, whilst the research processed the method of gender standardization when making a statistical analysis to decrease the influence of gender imbalance between the groups on the intervention effectiveness as much as possible, and eight[27,32-35,39,42,43] reported similar gender distribution in the intervention and control groups. We used the information about gender provided by two studies[28,37] to test the gender distribution in the intervention and control groups, and the remaining five studies[29,31,38,40,41] did not provide adequate information about gender to enable this comparison. Twelve studies[31-37,39-43] reported no statistical difference in the prevalence of obesity in the intervention and control groups at baseline.

Table 1. Detailed description of studies primarily on obesity intervention in China

Authors and publication date	Participants	Intervention district	Intervention mode	Intervention duration	Experimental group (n/N)		Control group (n/N)		Jadad score			
					Before	After	Before	After	R	C	B	W
Yang et al 2013[27]	S, P, T	Shanghai	N, PA, H	One year	96/833	76/806	12/234	13/234	2	1	0	1
Zhang et al 2010[30]	S, P, T	Guangzhou	N, PA	Four years	566/4046	60/3352	None		†	†	†	†
Zheng et al 2010[33]	S, P, T	Shanghai	N, PA	One year	75/744	75/744	82/749	115/749	1	0	0	0
Hu, Li 2011[34]	S, P, T	Jinan	N, PA	One year	157/643	122/601	149/667	143/617	1	2	0	0
Yuan, Xu 2011[35]	S, P, T	Jinan	N, PA, H	One year	212/696	126/601	147/663	127/617	1	0	0	0
Sheng et al 2006[28]	S	Shanghai	N, PA, H	Six months	295/1120	246/1120	121/630	113/630	1	0	0	0
Wang et al 2008[36]	S, P, T	Wuhan	N, PA, H	Ten months	84/812	91/728	45/467	46/422	1	0	0	0
Jiang et al 2002[37]	S, P	Beijing	N, PA, H	Three years	270/1597	192/1559	369/2118	474/2045	1	0	0	1
Tian et al 2006[31]	S, P	Changchun, Urumchi, Xian, Xiamen	N, PA, H	One year	270/1728	177/1701	254/1911	242/2179	0	0	0	0
Chen, Yang 2007[38]	S, P	Xiamen	N, PA, H	Two years	235/820	102/820	226/820	226/820	0	0	0	0
Duan et al 2008[40]	S, P, T	Beijing	N, PA	Two years	90/570	72/553	80/615	65/593	0	0	0	0
Shi et al 2004[42]	S	Beijing	N, PA	Two years	106/747	119/747	89/755	94/755	0	0	0	0
Han et al 2008[32]	S, P, T	Shanghai	N, H	Three years	187/1333	209/1328	175/1345	212/1342	1	0	0	0
Li et al 2004[29]	S	Shenzhen	N, PA, H	One year	69/468	66/458	32/335	45/335	0	0	0	0
Liu et al 2012[41]	S, P, T	Shandong	N, PA, H	Ten months	129/826	100/826	128/814	201/814	1	0	0	0
Wang et al 2005[39]	S, P, T	Guangxi	N, H	Seven months	4/125	2/124	1/120	0/117	2	0	0	1
Jiang et al 2007[43]	S, P	Beijing	N, PA	Three years	120/1029	81/1029	161/1396	186/1396	1	1	0	1

S: students; P: parents; T: teachers; N: nutrition education; H: health education, mainly targeting at improving lifestyle; PA: physical activity; R: randomization; C: concealment; B: blinded; W: withdraw or drop-out
†Pre- and post-test repeated-measures design, that was not appropriate to us Jadad Score Scale to evaluate its design.

Table 2. Limitations of studies of obesity nutrition interventions in China

Authors and publication date	Equivalence of group characteristics at baseline			Sample size estimation	The consistency of participants before and after intervention	Description of withdrawal	Description of group allocation method
	Sex	Age	Obesity prevalence				
Yang et al 2013[27]	B	B	UB	Y	Consistent	Describe missing data	Lottery
Zhang et al 2010[30]	n/a†	n/a†	n/a†	N	Inconsistent	No missing data	Non random
Zheng et al 2010[33]	B	B	B	N	Consistent	No missing data	None
Hu, Li 2011[34]	B	II	B	N	Consistent	Do not describe missing data	Lottery
Yuan, Xu 2011[35]	B	B	B	Y	Consistent	Do not describe missing data	None
Sheng et al 2006[28]	B	II	B	N	Consistent	Do not describe missing data	None
Wang et al 2008[36]	B	B	B	N	Consistent	Do not describe missing data	None
Jiang et al 2002[37]	B	II	B	N	Consistent	Describe missing data	None
Tian et al 2006[31]	II	B	B	N	Inconsistent	No missing data	Non random
Chen, Yang 2007[38]	II	II	B	N	Consistent	No missing data	Non random
Duan et al 2008[40]	II	II	B	N	Consistent	Do not describe missing data	Non random
Shi et al 2004[42]	B	B	B	N	Consistent	No missing data	Non random
Han et al 2008[32]	B	B	B	N	Inconsistent	Do not describe missing data	None
Li et al 2004[29]	II	II	B	N	Consistent	Do not describe missing data	Non random
Liu et al 2012[41]	II	II	B	N	Consistent	No missing data	None
Jiang et al 2007[43]	B	B	B	N	Consistent	No missing data	None
Wang et al 2005[39]	B	B	B	N	Consistent	Do not describe missing data	Lottery

B: balanced; UB: unbalanced; II: inadequate information; Y: provide sample size estimation; N: do not provide sample size estimation; None: mention randomization but do not describe the randomization process.
†Pre and post test repeated- measures design that did not need a test of group differences at baseline.

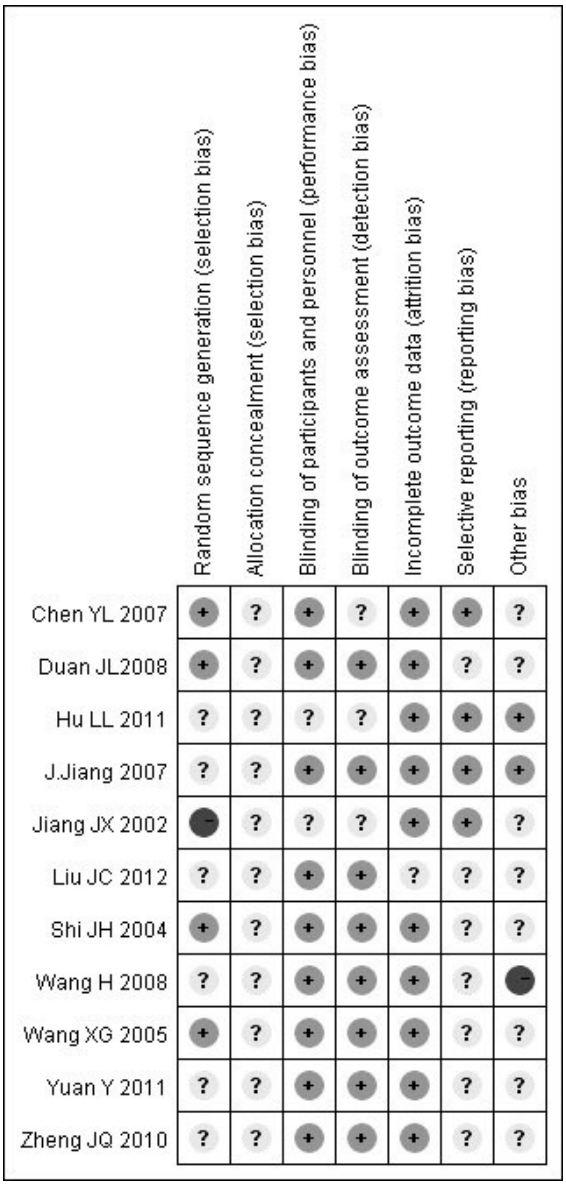

Figure 2. Risk of bias summary for studies of obesity intervention. "+": low risk of bias; "?": unclear risk of bias; "-": high risk of bias.

In the study of Li et al[29] the prevalence of obesity was higher in the intervention group than in the control group; however, there was no statistical difference between two groups after intervention, and based on this, the authors made a conclusion that the nutrition education played a role in controlling obesity. We tested the prevalence of obesity between the two groups for the other three studies[27,28,38] and found no statistical difference in one study,[38] but the prevalence of obesity was higher in the intervention group than in the control group at baseline in the remaining two studies.[27,28]

Three studies[30-32] did not analyze the prevalence of obesity in the same subjects before and after the intervention, which would lead to selection bias. Zhang et al[30] selected primary school children aged 6-13 years from three schools in 2001 as the subjects. In 2005, after 5 years of nutrition education, they again extracted primary school children aged 6-13 years from the same schools as the participants. Finally, they compared the prevalence of obesity between the selected participants in 2001 and those in 2005 to evaluate the effectiveness of nutrition education. However, there were differences in the participants between 2001 and 2005 because the majority of students had graduated over the 5 years and the participants selected in 2005 were mostly a new entry of primary school children. A limitation similar to that described for the study by Zhang et al[30] was also found in the control groups of the other two studies.[31,32]

We conducted a quantitative analysis of the 17 selected studies. The odds of participants being obese in the combined intervention arms and the arms after intervention tended to be lower than that in the combined comparison arms and the arms before intervention, but there was no significant difference (OR=0.76; 95% CI=0.55-1.05; p=0.09). Considering that group differences at baseline can influence the estimated effect of an intervention, we excluded the three studies[27-29] with such defects in methodology. Although five studies[29,31,38,40,41] did not provide information on gender distribution in the two groups and seven studies[28,29,34,37,38,40,41] did not provide information on age at baseline, the intervention and control groups of these studies were comparable according to other factors such as educational facilities, academic environment, the region's economy, and school size; therefore, we considered these studies to have equivalent group characteristics at baseline. We combined the results of 14 studies,[30-43] after excluding three studies[27-29] with the above mentioned defects in methodology, and found that the odds of being obese were significantly lower in the intervention group than in the control group after the intervention (OR=0.67; 95% CI=0.47-0.96; p=0.03). Therefore, we found that group differences at baseline influenced the estimated effect of nutrition education. Three of the 17 studies[30-32] had different subjects at different time points. After these three studies were excluded, the pooled OR of the remaining was 0.73 (95% CI=0.55-0.98; p=0.03) in a random effects model and the heterogeneity (I^2) was 90% (Figure 3).

After we excluded six studies[27-32] with the defect of group differences at baseline or selection bias, we made a funnel plot of the remaining 11 studies indicated that the publication bias was acceptable. In addition, we performed a quantitative analysis using the six studies[27-32] with low validity and the OR was 0.79 (95% CI=0.36-1.73; p=0.55). We speculate that the unbalanced baseline characteristics and selection bias of participants influenced the evaluation of the intervention effect.

Sample size calculation

Amongst the 17 selected studies, only two[27,35] performed a sample size calculation. The other studies did not mention the methods used to estimate sample size and we speculate that the sample size primarily depended on the subjective decision of the researcher.

Randomization

Among the 17 selected studies, only three[27,34,39] described their randomization method as a lottery. Eight[28,32,33,35-37,41,43] reported random allocation, but did not describe how they achieved randomization. These are considered to be quasi-randomized control trials.[44] The remaining six

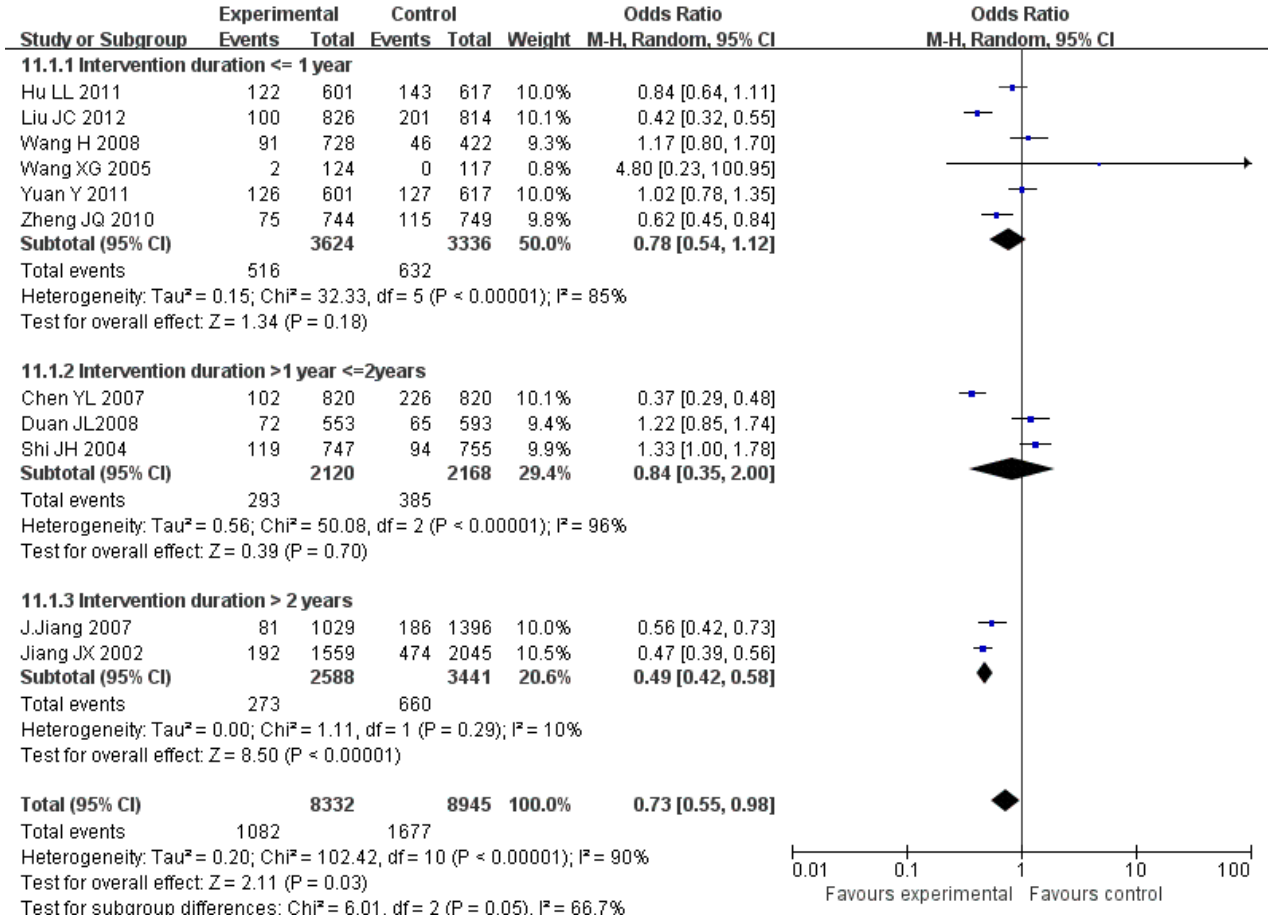

Figure 3. The forest plot of obesity intervention effect.

studies did not describe their method of allocating participants to groups.

We excluded six studies[27-32] that had unbalanced baseline characteristics or selection bias in participants, and divided the remaining 11 studies[33-43] into two strata: with and without proper randomization. We performed a meta-analysis for each strata. The pooled OR was 0.68 (95% CI=0.51-0.91; p=0.009) for the randomized trials and 0.84 (95% CI=0.35-2.00; p=0.70) for the non-randomized trials. These results indicated that randomization influenced the estimate of the intervention effect.

Intervention duration

There was high heterogeneity (I^2=90%) in the remaining 11 studies[33-43] after excluding studies[27-32] with unbalanced baseline characteristics or selection bias in participants. The duration varied from 6 months to 4 years. Because of the substantial heterogeneity, we categorized studies according to the duration of the intervention and performed a subgroup analysis. When we performed a meta-analysis of the two studies in which the intervention duration was more than 2 years, the likelihood of obesity was lower in the intervention group than in the control group (OR=0.49; 95% CI=0.42-0.58; p<0.001). There was no significant difference in the likelihood of being obese between the intervention and control groups when the intervention duration was less than 1 year (OR=0.76; 95% CI=0.54-1.09; p=0.14; n=6) or 1-2 years (OR=0.84; 95% CI=0.35-2.00; p=0.70; n=3) (Figure 3).

Withdrawal bias

Among the 17 selected studies, nine had missing data, but only two[27,37] described the individuals lost to follow-up. Withdrawal bias was not well discussed.

Ethics

Among the 17 selected studies, only one[43] reported having obtained informed consent for the intervention. The other 16 studies did not provide this information.

Comparative analysis

To ensure the validity of the meta-analysis, we set up rigorous inclusion and exclusion criteria for identifying studies of interventions aimed at preventing childhood malnutrition or iron-deficiency anemia (Figure 1), and eventually included three studies[39,45,46] about childhood malnutrition and six studies[47-51] about childhood iron-deficiency anemia (Tables 3 and 4). Making a meta-analysis, we found interventions aimed at preventing childhood malnutrition (n=3) had a pooled OR of 0.68 (95% CI=0.64-0.71; p<0.0001)[39,45,46] and those aimed at preventing iron-deficiency anemia (n=5) had a pooled OR of 0.49 (95% CI= 0.33-0.72; p<0.001).[47-51] By comparison, the impact of nutrition education interventions aimed at preventing obesity was smaller.

DISCUSSION

The prevalence of adolescent obesity in developed countries is high and increasing, highlighting the urgent need

Table 3. Detailed description of studies on malnutrition intervention in China

Authors and publication date	Participants	Intervention district	Intervention mode	Intervention duration	Experimental group (n/N)		Control group (n/N)		Jadad score			
					Before	After	Before	After	R	C	B	W
Wang et al 2005[39]	S, P, T	Guangxi	N, H	Seven months	7/125	4/124	13/120	15/117	2	0	0	1
Fu 2004[46]	S, P, T	Fujian	N	Five months	355/1023	267/1023	367/939	325/939	1	0	0	0
He et al 2001[45]	S, P	Fuyang	N, H	Three months	3105/19465	2223/19465	None		†	†	†	†

S: students; P: parents; T: teachers; N: nutrition education; H: health education, mainly targeting at improving lifestyle; R: randomization; C: concealment; B: blinded; W: withdraw or drop-out.
†Pre- and post-test repeated-measures design, that was not appropriate to us Jadad Score Scale to evaluate its design.

Table 4. Detailed description of studies on iron deficiency anemia intervention in China

Authors and publication date	Participants	Intervention district	Intervention mode	Intervention duration	Experimental group (n/N)		Control group (n/N)		Jadad score			
					Before	After	Before	After	R	C	B	W
He et al 2008[48]	S	Sichuan	N	Three months	47/145	16/145	33/113	31/113	1	0	0	0
Maimaiti et al 2009[50]	S	Urumchi	N	Five months	64/195	51/216	75/235	87/240	1	0	0	1
Ding, Yang 2000[47]	S, P	Gansu	N	Three years	385/862	373/1011	98/216	111/253	0	0	0	0
Zhao et al 2006[51]	S, P	Yunnan	N	Six months	26/65	7/66	27/60	24/61	1	0	0	0
Huang et al 2005[49]	S	Shenzhen	N	Eight months	41/422	24/422	None		†	†	†	†

S: students; P: parents; N: nutrition education; R: randomization; C: concealment; B: blinded; W: withdraw or drop-out.
†Pre- and post-test repeated-measures design, that was not appropriate to us Jadad Score Scale to evaluate its design.

to identify effective interventions. In a recent survey, 65% of American citizens believed that schools have a major role to play in tacking the obesity epidemic and only 7% believed that the school had no role to play at all.[52] The National Institute for Health and Clinical Excellence[53] guidelines also recommended school-based interventions.

The effects of nutrition education delivered in schools on adolescent obesity have been widely studied in China. However, we found that randomization was often not implemented, which may be due to inadequacy of study design or reporting. There are several possible reasons for this. Researchers might not have recognized the importance of randomization, or might have had difficulties fully implementing randomization. Alternatively, some subjects might not have been willing to participate in the experiment, resulting in an incomplete allocation. From the aspect of research reporting, journals might have had word limits that precluded a detailed description of the research methods. We strongly suggest reporting research results in line with the Consolidate Standards of Reporting Trials (CONSORT) Statement,[54] an international unified standard for reporting randomized controlled trials.

Another important issue is whether the studies had balanced intervention and control groups. Ideally, there should be no statistical difference in the prevalence of obesity, gender, age, and other characteristics between two groups at baseline. When randomization is not properly performed or the sample size is small, there may be differences between the groups at baseline. Multivariate analysis should be used to deal with potential confounding. Among the four studies with unbalanced groups, only one had gender standardization. The other three studies did not properly handle the group differences.

Loss to follow-up was not uncommon in the selected studies. Participants were free to withdraw from the study at any time, and retention usually decreases as the length of the study increases. An increasing workload might have forced some children to withdraw from the study. We suggest that some rewards be given to children to improve their interest in such trials. Alternatively, nutrition education could be included as a regular part of the curriculum.

Multiple strategies were incorporated into the obesity interventions delivered to school children in China. In several studies, the interventions not only targeted schoolchildren, but also engaged parents, teachers, and school personnel. The interventions consisted of nutrition intervention, health education, and physical activity, and comprehensive approaches were aiming at facilitating dietary behavior changes and increasing physical activity. Intervention diversification provides multiple opportunities to reduce the risk of childhood obesity. However, the effect of these interventions on childhood obesity was not satisfactory. Six of the 17 included studies found no statistical difference in the prevalence of obesity between intervention and control groups after the implementation of school-based nutrition education. One possibility is that the intervention and observation duration were too short. Most of the 17 studies had duration of less than 1 year; however, a healthy lifestyle and diet habits are gradually cultivated based on knowledge-attitude-behavior patterns, and require adequate time. As a result, intervention duration is a critical factor in obesity-control interventions. We found that nutrition education had an effect on childhood obesity only when the intervention duration was more than 2 years. Another meta-analysis[55] reported that nutrition education reduced the risk of obesity only when the duration was 1-2 years. Although differences in the body composition of primary school children across countries[56] may explain this discrepancy, this result also indicates that there is much space to improve nutrition education interventions in China. Interventions delivered in China did not obtain the same effect as similar programs overseas, which is a waste of human, financial, and material resources.

In terms of nutrition education strategy itself, the content of Chinese nutrition education is relatively fixed, fragmented and has poor systematic structure compared with that of overseas nutrition education. In China, we need to increase the penetration of nutrition education in various types of school courses, or set up a short, independent nutrition education course with the support of the school educational administration management system to ensure early implementation of a school-based nutrition education intervention. Regional differences in economics, culture, and government policy will also affect the popularity of nutrition education interventions in schools. We also performed a subgroup analysis according to the region. The combined OR of four studies in the south of China was 0.69 (95% CI=0.37-1.29; p=0.24) compared with 0.76 (95% CI=0.53-1.07; p=0.12) for seven studies in the north, indicating there is no difference in the effectiveness of school-based nutrition education for childhood obesity between the south and north of China.

Compared with the effect of interventions on the prevalence of childhood malnutrition and iron-deficiency anemia, the effect of interventions on the prevalence of childhood obesity was minimal. One reason may be the short duration of the obesity intervention programs, which reflects that the improvement of obesity is a step-by-step process. This may also reflect the fact that not enough importance has been attached to adolescent obesity, and that the understanding of obesity as a disease is poor among Chinese people, especially Chinese parents.

Most parents do not consider obesity to be a disease, and do not correctly supervise their children's living habits. They provide a suboptimal diet for their children that include high calorie content, which is a huge obstacle to achieve the goal of nutritional health education. Caregivers' attitudes toward weight and how caregivers deliver information on weight issues to children should be recognized as important and related to healthy body image and eating attitudes among children.[57]

Although the interventions aimed at preventing malnutrition and iron-deficiency anemia in primary school children in China seemed to be more effective than the interventions aimed at reducing obesity, studies of the effectiveness of these interventions had similar limitations to those discussed above for childhood obesity interventionstudies. In addition, the etiological factors of malnutrition and iron-deficiency anemia in children vary in different parts of the country. Inadequate dietary intake is a

primary reason for malnutrition and iron-deficiency anemia for children in rural areas, whereas the adoption of a more Westernized lifestyle combined with limited knowledge of a healthy diet is an issue for children in urban areas. However, most studies have not taken regional differences into account. It may be necessary to modify nutrition education models on the basis of these differences to achieve optimal results.

This meta-analysis identified several limitations of existing studies of school-based nutrition education that were associated with the estimated effectiveness of nutrition education interventions on childhood obesity. In future research, school principals and policymakers should consider implementing school-based interventions as long-term strategies for preventing and managing adolescent obesity. Studies that aim to evaluate the effectiveness of these interventions should ensure proper randomization, appropriate sample size, and similarity of groups at baseline, as these are the key factors that influence the reliability of the experimental results. The government and associated institutions should realize that individual cognitive-based strategies alone are unlikely to create sustainable behavior changes and that childhood obesity-related knowledge amongst the public, especially amongst caregivers, must be increased to generate change in the social and physical environment as well as individual education and personal change.[14]

There are some limitations in our study. The included studies mostly used weight-for-height and BMI to define obesity, and evaluated the effectiveness of the intervention using the prevalence of obesity rather than more sensitive indicators such as changes in the BMI. Similar restrictions also existed in studies of malnutrition and iron-deficiency anemia interventions. Another important limitation is that we did not control for some important confounding factors. For example, as we conducted a stratified analysis according to the type of randomization, we did not control the influence of sample size calculation, intervention duration, and important confounding factors such as gender and age.

In conclusion, there is no denying that school-based nutrition education is a feasible and cost-effective strategy that helps children develop healthy habits at early age and contributes to combating childhood obesity. However, there are limitations to the relevant research in China, and the quality of the studies in this area needs to be improved.

AUTHOR DISCLOSURES

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Original Article

Limitations of studies on school-based nutrition education interventions for obesity in China: a systematic review and meta-analysis

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中国基于学校对小学生肥胖营养教育干预研究的局限性：系统综述和 meta 分析

背景与目的：面对近年来小学生肥胖发病率的不断增长，基于学校的营养教育在中国广泛开展。**方法与研究设计：**利用万方、CNKI、CBM、Pubmed、ISI Web of Knowledge 和 Embase 六个数据库，对中国基于学校针对小学生肥胖的营养教育的相关文献进行检索。对纳入的文献进行方法学和偏倚风险的评估，并采用分层分析的方法探索不同方法是否会对干预效果的评估产生影响。**结果：**共有 17 篇文献纳入分析，其中有几个研究存在干预时间不足、随机化方法不当、选择偏倚、干预组和对照组某些基线特征不均衡，以及缺乏样本量的计算等问题。总体而言，相对于针对小学生营养不良的基于学校的营养教育干预结果 OR 为 0.68，以及缺铁性贫血的干预结果 OR 为 0.49，基于学校的营养教育对小学生肥胖没有显著影响（OR=0.76，95% CI=0.55-1.05；p=0.09）。当排除存在研究对象组间某些基线特征不均衡和选择偏倚的相关文献后，再次分析发现营养教育对肥胖的干预效果显著（OR=0.73，95% CI=0.55-0.98；p=0.003）。另外，根据干预时间进行分层分析，我们发现只有当干预时间>2 年时，基于学校的营养教育才对小学生的肥胖有效（OR=0.49，95% CI=0.42-0.58；p<0.001）。**结论：**中国基于学校的针对小学生肥胖的研究有一些重要的局限性，可能会影响干预效果的评估。

关键词：营养教育、小学生、肥胖、系统综述、meta 分析