

## Tracking of Interventions on Overweight and obese School Children: a Systematic literature review (2000-2014)

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### Abstract

Childhood obesity predisposes to adult obesity and increases the risk of many chronic diseases including type II diabetes, hypertension, cardiovascular disease as well as some types of cancer. This systematic review aimed to determine the effectiveness of diverse approaches used in dietary and physical activity based interventions in dealing with obesity among children. PUBMED, Science Direct, Scopus and Google Scholar digital databases were searched (January 2000 to December 2014) for longitudinal and randomized controlled trials with minimum duration of 6 weeks reporting weight changes as primary outcomes. Overall, 18 out of 27 studies are considered as “effective” based on a statistically significant reduction in body mass index (BMI) or skin-folds for the intervention group (IG). Growing evidence showed that school-based interventions which incorporate physical activity, parent’s involvement and using more interactive and enjoyable intervention as a complement to nutrition education may help prevent children becoming overweight in the long term. This review provided an update of the evidence from studies designed to evaluate the interventions to prevent childhood obesity. However, a more innovative and attention captivating intervention such as in the form of serious video games are needed to enhance the effectiveness of conventional interventions targeting at children.

**Keywords:** childhood obesity; nutrition education; primary school children; school-based interventions.

### Introduction

The increasing prevalence of childhood obesity in Malaysia possessed a major threat to the public health. This health problem is a result of imbalance between energy intakes and energy expenditure due to unhealthy diet, decreased levels of physical activity (PA) and sedentary lifestyles [1]. Obesity increases the risk of numerous chronic diseases including diabetes, hypertension, cardiovascular diseases and several types of cancer; thus, special attention should be paid to its prevention. Overweight or obese youth are less likely to compensate for excess energy intake throughout the day than normal-weight children [2]. Investigating the various strategies that reduce overweight and obesity by aiming healthy eating and PA is a crucial endeavour.

School is an ideal place to teach children about healthy eating as most children spend the greatest part of their time in school. It is the time when they are developing eating habits that provide the basis for eating patterns throughout their lives [3]. Quite large proportions of obesity prevention programmes have been carried out in schools reference. Thus, many studies have been published more recently. Therefore, we conducted an up-to-date review of published studies that evaluate the impact of nutrition education (NE) interventions on the body mass index (BMI) school children.

### Methods

#### Search strategy

Studies published between January 2000 and December 2014 was searched from PUBMED, Science Direct, Scopus and Google Scholar. Reference lists from review articles and eligible original articles were also searched manually to identify any additional articles. Keywords used as “nutrition education/health education and promotion/obesity prevention/ intervention” AND “school children/overweight/obese/BMI” AND “school programme/school intervention”.

The search was limited to articles focusing school children population with restricting inclusion criteria to interventions with

longitudinal, exploratory and randomized controlled trial (RCT) design. Included articles must have taken anthropometric measurement of body weight and should aim at decreasing BMI or weight.

A total of 78 articles were identified from electronic databases, other publications as well as from cross references. Of these, 51 were excluded due to the study design, measure other effect rather than BMI as primary outcome, the study published other languages and the outcomes presented in the dissertations, review articles and brief reports. Finally, only 27 studies met all the inclusion criteria and were included in this review. Literature search are summarized in Figure 1.

### Results

The 27 studies were published between 2001 and 2014 and included a total of 18,545 participants. Six studies were conducted in the United States of America, five in United Kingdom, three in Germany, two in Brazil, China, Israel and Netherlands respectively and one study in Chile, France, New Zealand, Australia and Switzerland respectively. Most of the studies (19 studies) were long-term experiments (9 months – 7 years) and the rest were short-term interventions (6 weeks – 6 months). The sample sizes varied greatly among the studies ranging from 60 to 3086 participants – Table 1.

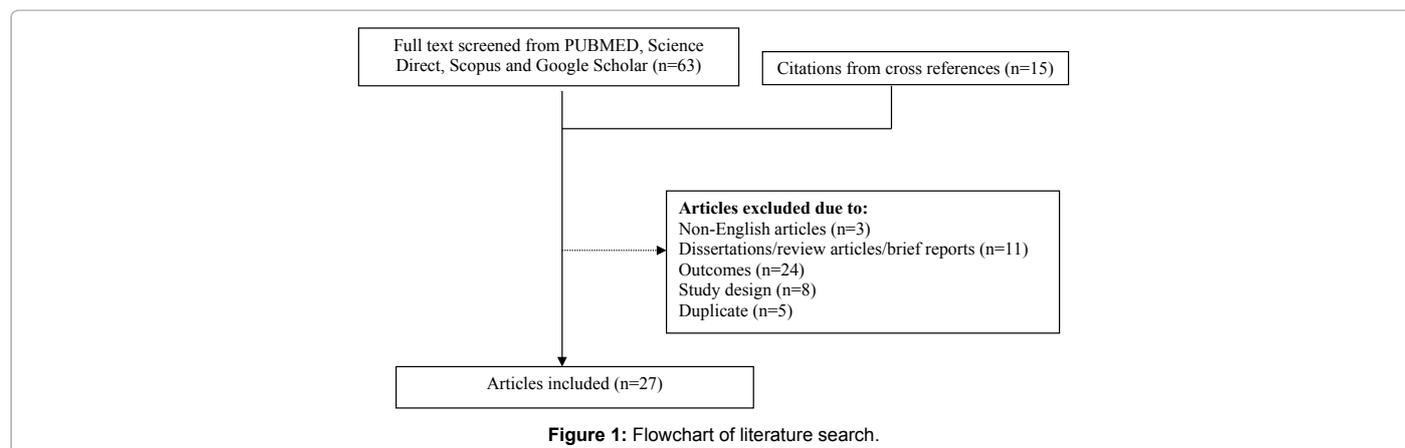
All of the interventions were conducted in school premises except for seven studies which conducted at paediatric obesity clinic, student

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**Received** August 28, 2015; **Accepted** September 25, 2015; **Published** September 30, 2015

**Citation:** Wan Putri Elena WD, Hamid Jan JM, Hafzan Y (2015) Tracking of Interventions on Overweight and obese School Children: a Systematic literature review (2000-2014). Health Care Current Reviews 3: 140. doi: [10.4172/2375-4273.1000140](https://doi.org/10.4172/2375-4273.1000140)

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Author, country (year)	Study design, duration	Respondents	Intervention programme	Results	Limitations
<b>DIET ONLY STUDIES</b>					
Cunha et al., Brazil (2013) [17]	Cluster RCT trial, 9-month	559 (IG=277, CG=282)	9 NE sessions including playing games, staging of theater sketches, watching movies and puppet shows, and writing and drawing contests	- Decreased sugar-sweetened beverages consumption - Increased fruits consumption - Motivation to change eating habits increased over time.	- Participant satisfaction was not measured - Dependent on memory (24hours and FFQ)
Muckelbauer et al., Germany (2009) [13]	Cluster RCT, 1-year	2950 (IG=1641, CG=1309)	Combined environmental and educational intervention promoting water consumption	- The risk of OW was significantly reduced by 31% in the IG	- Did not evaluate dietary behaviors
James et al., UK (2007) [15]	Cluster RCT, 2-year	434 (IG=219, CG=215)	Focused education promoting a healthy diet and discouraging the consumption of carbonated drinks	- BMI had decreased in IG - The prevalence of OW increased in both IG and CG	- High dropout rate - Consumption of carbonated drinks was not measured
James et al., UK (2004) [14]	Cluster RCT, 1-year	644 (IG=325, CG=319)	Focused on the balance of good health and promotion of drinking water, tasted fruit to learn about the sweetness of natural products, music competition, presentations of art and quiz	- The percentage of overweight and obese as well as consumption of carbonated drinks decreased	- Contamination of RCT due to the randomization was according to classes not schools
Sichieri et al., Brazil (2008) [18]	Cluster RCT, 1-year school (10 months)	1140 (IG=435, CG=608)	Healthy lifestyle education using simple messages encouraging water consumption instead of sugar-sweetened carbonated beverages	- Non-significant reduction overall BMI among children in IG - But significantly reduced BMI among girls who were OW in IG - Significantly decreased the consumption of carbonated drinks in IG	- Slight family involvement - Intervention may not have been sufficiently intense or long enough to change behavior

FFQ=Food Frequency Questionnaire; BMI=Body Mass Index; RCT=Randomized Controlled Trial; NE=Nutrition Education; IG=Intervention Group; CG=Control Group; OW=Overweight

Author, country (year)	Study design, duration	Respondents	Intervention programme	Results	Limitations
Golan & Crow, Israel (2004) [6]	Randomized and longitudinal, 7-year	60 (IG=30, CG=30)	14 1-hour support and educational group sessions; limits of responsibilities, NE, eating and activity behavior modification, decreasing stimulus exposure, parental modeling, problem solving, cognitive restructuring and coping with resistance	Significant greater reduction of OW children in IG compared to CG	Small sample size
<b>PA ONLY STUDIES</b>					
Kriemler et al., Switzerland (2010) [19]	Cluster RCT, 1-year	502 (IG=297, CG=205)	Three existing PE lessons a week, daily short activity breaks and PA homework	- Significantly improved PA and fitness in IG - Small increments of BMI and waist circumference	No nutritional assessment
Thivel et al., France (2011) [20]	Randomized and longitudinal, 6 months	457 (IG=229, CG=228)	120 minutes of supervised physical exercise and 2 hours of PE classes per week	Improved significantly in terms of aerobic and anaerobic physical fitness	No nutritional assessment
<b>COMBINED DIET AND PA STUDIES</b>					
Sahota et al., UK (2001) [21]	Cluster RCT, 1 year	636 (IG=314, CG=322)	Teacher training, modification of school meals, and the development of school action plans targeting the curriculum, PE, tuck shops and playground activities	- Vegetable consumption was increased among IG. - Unsuccessful in reducing risk factors for obesity	- Difficult to measure the accurate dietary assessment - Difficult to quantify the PA level

PA=Physical activity; PE=Physical education

Author, country (year)	Study design, duration	Respondents	Intervention programme	Results	Limitations
Kain et al., Chile (2004) [22]	Longitudinal controlled evaluation study, 6 months	3086 (IG=2141, CG=945)	NE for children and parents, 'healthier' kiosks, 90 min of additional PA weekly, behavioral PA program and active recess.	Positive effect on adiposity indices in boys while physical fitness parameters increased in both boys and girls (<0.001)	Non-randomized trial
Savoie et al., Israel (2007) [23]	RCT, 1 year	174 (IG=105, CG=69)	Intensive family-based program including exercise, nutrition and behavior modification	Significant reduction in BMI and body fat	- High dropout rate - No measurable change in calories or macronutrients
Foster et al., USA (2008) [24]	RCT, 2 years	844 (IG=479, CG=365)	School Nutrition Policy Initiative includes: school self-assessment, NE, nutrition policy, social marketing and parent outreach	The prevalence of OW was lower in the IG schools	The use of self report measures of diet and exercise is less ideal than direct measures
Jiang et al., China (2007) [7]	RCT, 3 years	2425 (IG=1029, CG=1396)	NE and PA through classes, educational materials and text with 10 themes. Including parents in IG	- Prevalence of OW and obesity were significantly reduced in IG. - BMI did not decrease significantly among severe obese children during the intervention.	Dietary intake, PA and obesity-related behaviours were not measured
Sacher et al., UK (2010) [25]	RCT, 12 months	116 (IG=60, CG=56)	MEND is a multicomponent community-based childhood obesity intervention	- Significant reduction of waist circumference and BMI in IG - Significant improvements for BP, PA level, self-esteem and heart rate	- High dropout rate - Lack of blinding for measurement of outcomes

BP=Blood pressure

Author, country (year)	Study design, duration	Respondents	Intervention programme	Results	Limitations
Boutelle et al., USA (2012) [26]	RCT, 11 months	80 (IG=40, CG=40)	5-month family based behavioral weight loss program includes dietary modification, increases in PA, behavioral change skills and parenting skills.	Reduction of 1 BMI unit in the parent was associated with a 0.255 reduction in child BMI.	Unmeasured variables may act as confounders that bias the observed effects.
Caballero et al., USA (2003) [27]	RCT, 3 years	1704 (IG=879, CG=825)	The intervention had four components: i) classroom curriculum, ii) food service, iii) physical activity and iv) family involvement	- No significant reduction in body weight and BMI - Knowledge, attitudes and behavior were positively and significantly changed.	High dropout rates
Vos et al., Netherlands (2011) [28]	RCT, 1 year	81 (IG=41, CG=40)	Multidisciplinary lifestyle treatment including medical, nutritional, physical and psychological counseling	- Significant reduction of BMI in IG - Significant improvements of HRQoL	Intervention used was expensive
Schaefer et al., Germany (2011) [29]	RCT, 2 years	76 (pilot=19, IG=34, CG=23)	"Obeldicks light" based on PA training, NE and behavior counseling for overweight children and their parents	- Skin fold thickness, BIA, waist circumference and BP significantly decreased. - All the measurements remained stable in the follow-up period	High drop-out rates

HRQoL=Health-related Quality of Life; BIA=Bioimpedence analyses

Author, country (year)	Study design, duration	Respondents	Intervention programme	Results	Limitations
Warren et al., UK (2003) [30]	RCT, 20 weeks	218 (IG i=56, ii=54, iii=54, CG iv=54)	Consisted of: i) Eat Smart, ii) Play Smart, iii) Eat Smart Play Smart and iv) Be Smart	- Significant of nutrition knowledge among group "Eat Smart" and "Eat Smart Play Smart" - Fruit and vegetable intake increased significantly in group i and iv. - No significant changes in the rates of OW and obesity	- Duration of the study was not adequate. - Assessment of diet, PA and nutrition knowledge may not have been sensitive enough - Four interventions were conducted in each of the schools, may have led to contamination between IG - Problems in targeting parents
Morgan et al., USA (2014) [31]	Longitudinal, 10 weeks	106 (IG=51, CG=54)	i) Classroom NE to improve nutrition KAB, ii) classroom PA to increase fitness and EE, iii)a unique technology-based component using avatars to improve motivation, body image and self-esteem	- No significant changes in BMI, food self-efficacy and actual food intake - Improved their healthy food choice intentions - Ability to identify fatty foods and general nutrition knowledge	- Short time of intervention - No follow up
Coleman et al., USA (2005) [32]	Untreated, matched control group design, 3 years	896 (IG=423, CG=473)	Community-based implementation of the national Coordinated Approach To Child Health (CATCH) programme	No effect on weight from year to year	- High dropout rate - No measurement on dietary intake

KAB=Knowledge, attitude, behavior; EE=Energy expenditure

Author, country (year)	Study design, duration	Respondents	Intervention programme	Results	Limitations
Hofsteenge et al., Netherlands (2014) [33]	RCT, 18 months	122 (IG=71, CG=51)	Education on healthy dietary, sedentary and PA for 7 sessions (duration 90 minutes) with an interval of 2 to 3 weeks	- Significant reduction in BMI SDS - No significant effect in body composition or metabolic components	- High level of drop out - No exercise programme provided
Luo et al., China (2013) [34]	RCT, 6 weeks	167 (IG=95, CG=72)	Received well-defined and balanced daily meals and engaged in high volumes of moderate exercise (6days/week, twice daily for 3 hours per session)	Significantly reduced levels for all outcome markers except for FBI in boys	- Short-term period - No follow-up assessment
Small et al., USA (2013) [35]	RCT, 6 months	60 (IG=33, CG=27)	Establishment of healthy habits in young children, nutritional information, information regarding increasing PA and decreasing sedentary time	Reduction of waist circumference in IG	Small sample size
Graf et al., Germany (2008) [36]	Longitudinal, 4 years	611 (IG=433, CG=178)	Children's Health Interventional Trial (the CHILT Project) combines health education and PA for children	- No difference in the prevalence of OW and obesity was found in IG and CG - Increment in endurance performance in IG	- Health knowledge and nutritional habit were not measured. - The schools were not randomly assigned to IG and CG

FBI=Fasting Blood Insulin

Author, country (year)	Study design, duration	Respondents	Intervention programme	Results	Limitations
Maddison et al., New Zealand (2011) [10]	RCT, 6 months	322 (IG=160, CG=162)	Upgrade (hardware and games) of existing gaming technology that enabled them to play active video games at home	Body fat and BMI in IG were significantly reduced.	- Self-developed food and video game diaries - Some children were recruited through schools, a potential for contamination
Trost et al., Australia (2014) [11]	RCT, 16 weeks	75 (IG=34, CG=41)	Game console and motion capture device and active game at their second treatment session and a second game in week 9 of the program	Participants in IG exhibited significantly greater reductions in percentage OW compared to CG.	Intervention is too expensive and may be a barrier for low-income families

**Table 1:** Details of the included intervention studies.

physical fitness, pediatric primary care and at home. Nine studies used a single intervention; two just physical educations and six just educations on nutrition. The remaining of eighteen studies used combination of these two or more interventions. Only ten studies have involved parents in their intervention. In total, 20 interventions included a physical component such as conducting moderate exercise including brisk walking, jogging and swimming, 21 interventions included education on nutrition or classroom lessons which receiving the nutritional information, information regarding increasing PA and decreasing sedentary time and establishment eating habits. Other than that, two studies included a counseling component, three studies involved video games components and two studies received cognitive behavioral therapy.

Eighteen studies are considered effective according to height/weight measures, skin-folds or both. More than half of the studies had a high percentage of participants completing the study and this may be a reflection of various factors such as small sample sizes, short-study periods and nature of the intervention.

## Discussion

This updated review provides useful data on published studies and expands the spectrum of information that should make it more useful for public health decision makers. Overall, the absolute reduction in BMI was greater for interventions targeted at overweight and obese children by using different types of interventions. There is accumulating evidence that school-based interventions can significantly reduce children's BMI, especially when including physical exercise components, parental involvements and using interactive, enjoyable but effective intervention to prevent the obesity.

In this review, 18 out of 27 studies considered as "effective" based on a statistically significant reduction in BMI or skin-folds for the intervention group (IG). Previously, more than half of the studies reviewed by Doak et al., [4] also showed a significant effect in reducing the prevalence of overweight and obesity. However, nine studies in this review were not successful in reducing the BMI. One possible reason for this situation is because it is difficult to make changes to behavior in an environment which increasingly promotes a high energy intake and sedentary activity [5].

There was sufficient evidence to conclude the influence of parental involvement in reducing their children's weight. Study conducted by Golan and Crow [6] has pointed out that a family-based, health-centered approach that targeted solely parents was found to induce greater weight loss in obese children. "Don't encourage your child to eat more when the child feels full" was a major message in the study for the parents to implement which was carried out by Jiang et al., [7] and showed the positive result in reducing the overweight and obesity among their children. Educating for both parents and their children, give the complex interactions between social determinants in a family setting which is essential to the success for an intervention [8]. Thus, the involvement of parents in educational process enables them to become suitable models for their children, assuming a key role in building their dietary habits.

Despite of the growing number of overweight and obese college students, few studies were not applied the PA components in their interventions. A research conducted by Franko et al., [9] has shown that limited PA could likely lead to the risk of osteoporosis, obesity, hyperlipidemia, diabetes and cancer in later life. Because of video games based nutrition programmes are relatively new, it is not surprising

that only few studies have been published in this area specifically for children. Only three studies [7, 10-11] have evaluated the effects of using video games and reported significant increases in daily PA. Serious video games offered innovative and enjoyable channels for effective behavior change. In addition, child's attentions have been attracted, modeling, tailoring, and feedback can increase personal relevance, and games add fun [12]. As such, the need for enjoyable, healthy and effective prevention of overweight and obesity is generally considered to be urgent.

Other findings that applied different components of education but effectively in reducing the BMI were also identified. One study in primary schools in deprived areas in Germany in which a reduction in overweight was found in intervention schools which received drinking water fountains with provision of drink bottles and related lessons [13]. Another study in UK which has involved children aged 7 – 11 years from primary schools found that educational sessions and activities designed to reduce carbonated drink consumption led to decrease in the percentage of overweight and obese children of 0.2% compared to an increase of 7.5% in the CG over a follow-up period of 12 months [14]. After two years, the same studies also provide the best result with experimentally conclusive and sustainable evidence [15].

In terms of methodology, there is a clear need for the continuation of research, using better and larger studies with a long follow-up and improved research methodologies. The findings from few studies in this review have not described whether the environmental changes made during the interventions are maintained subsequently. Baranowski et al., [16] has suggested that intensities and durations of intervention programme over extended periods of intervention made should be analyzed and evaluated to ensure the effectiveness of the interventions. In addition, the reliability and validity of the interventions were not comprehensively reported, elements which are essential for judging the effectiveness of the interventions.

### Limitations of this study

The majority of the included studies took place in the USA or northern Europe which limits the generalisability for the rest of the world, since the obesogenic environment is supported by increasingly complex social, political and cultural environments which may be unique to a particular country. In addition, the studies not indexed in PUBMED, Science Direct or Scopus and unpublished studies were not identified which is less-biased to provide more comprehensive review. Duration of the study can be a limiting factor for high dropout rate which can be seen in some intervention studies lasting over one year. Other than that, the instruments used in several studies were self-reported measures (except for the anthropometric measurements) which were highly dependent on the participants' memory, honesty and truthfulness in answering the questions. For this reason, the results may not reveal the actual dietary intake and eating behaviors of the participants and hence self-report bias may have occurred as the diet was unobserved.

### Conclusion

Despite the unavoidable limitations, encouraging and positive results have been demonstrated via most studies. The characteristics of the interventions that demonstrated effectiveness are as follows: duration longer than 1 year, involvements of parents, allied to PA components and introduction of interactive, healthy and practical intervention via video games rather than using traditional or conventional interventions which are more practical for the current generation nowadays.

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