School-based interventions for childhood and adolescent obesity

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Summary

The purpose of this article was to review population-based interventions for preventing childhood obesity carried out in school settings published between 1999 and 2004. A total of 11 such interventions were found from USA and UK. The grade of the interventions was from kindergarten, primary grades, middle school to high school. Most of these interventions targeted both physical activity and nutrition behaviours although there were some interventions that focused on only one dimension such as TV watching or restricting drinking of carbonated drinks or increasing physical education time in the school. Most of the interventions were based on some behavioural theory and the most popular theory was social cognitive theory. Most of the interventions focused on individual level behaviour change approaches. Most of the interventions focused on short-term changes right after the intervention. On the whole, interventions resulted in modest changes in behaviours and mixed results with indicators of obesity. TV watching seems to be most modifiable behaviour, followed by physical activity and nutrition behaviours. The outcome measures such as lowered BMI (body mass index), triceps skin-fold thickness and waist circumference have not been measured by all studies. Recommendations for enhancing the effectiveness of school-based childhood obesity interventions are presented.

Keywords: Children, nutrition, physical activity.

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Introduction

In the United States childhood overweight and obesity in both girls and boys is reaching epidemic proportions (1). The prevalence of overweight currently affects 24% of US children and adolescents (2). Since 1980 the prevalence of overweight has doubled for children and tripled for adolescents (1). African–American and Hispanic children have higher rates of overweight and risk for overweight than white children (3). Childhood overweight and obesity are particularly harmful as these persist in adolescence and adulthood (4,5). The dangers of being overweight or obese in childhood are well documented. The Bogalusa Heart Study found that by age 10 years, 60% of overweight children have at least one biochemical or clinical cardiovascular risk factor and 25% have more than two (6).

Childhood obesity is associated with several short-term medical consequences such as adverse blood lipid profile, altered glucose metabolism, obstructive sleep apnoea and long-term effects such as higher risk of hypertension, diabetes, cardiovascular disease, gall bladder disease and osteoarthritis in adulthood (5). Childhood overweight and obesity have also been linked with psychosocial ramifications such as poor self-image, lowered self-esteem, eating disorders and poor quality of life (7). The national health-care expenditures related to overweight and obesity in adults are estimated between $98 billion to 129 billion (8). Two of the determinant behaviours of obesity, unhealthy dietary habits and sedentary behaviour, together account for approximately 300 000 deaths every year (9). It has been suggested that obesity is second only to smoking as a preventable cause of death (10). Therefore, in the *Healthy*

People 2010 report, the goal for reducing overweight and obesity in children and adolescents is aimed at 5% from the 1988–1994 baseline of 11% (11). Likewise, in *Surgeon General's Call to Action to Prevent and Decrease Overweight and Obesity* published in 2001 various steps have been suggested to combat obesity at all levels (12).

Modifiable determinants of childhood obesity

Overweight and obesity are caused by various factors. Body weight is shaped by a combination of genetic, metabolic, behavioural, environmental, cultural and socioeconomic influences. For a large majority of individuals, overweight and obesity result from excess energy consumption and/or inadequate physical activity (12). According to the US Department of Agriculture's 1994–1996 Continuing Survey of Food Intakes by Individuals, very few Americans meet the majority of the Food Guide Pyramid recommendations (13). Only 3% of all individuals meet four of the five recommendations for the intake of grains, fruits, vegetables, dairy products and meats. Further, 45% of adults engage in the recommended amount of physical activity which comprises of moderate-intensity physical activity for greater than 30 min per day for 5 or more days of a week or vigorous intensity activities for greater than 20 min for 3 or more days a week, and 26% of adults engage in no leisure-time physical activity (14).

Commonly suggested modifiable public health strategies to combat childhood obesity are promoting breastfeeding, limiting television viewing, encouraging physical activity, increasing fruit and vegetable intake, controlling portion size and limiting soft drink consumption (15). However, the 2003 Youth Risk Behaviour Survey shows that the percentage of students who did not participate in at least 20 min of vigorous physical activity on 3 or more of the past 7 days and did not do at least 30 min of moderate physical activity on 5 or more of the past 7 days was 33.4%, the percentage of students who participated in no vigorous or moderate physical activity during the past 7 days was 11.5%, the percentage of students who attended physical education (PE) class daily was only 28.4%, the percentage of students who watched 3 or more hours of TV per day on an average school day was 38.2%, the percentage of students who ate five or more servings of fruits and vegetables per day during the past 7 days was 22%, the percentage of students who were at risk for becoming overweight was 15.4%, while the percentage of students who were overweight was 13.5% (16). Television viewing is considered among the most modifiable cause of childhood obesity (17,18). Three potential mechanisms operate in linking television viewing with obesity: (i) reduced energy expenditure due to physical inactivity; (ii) increased dietary intake due to cues from food advertisements; (iii) decreased resting metabolic rate during viewing (18).

Aims

It is in this backdrop that the aims of this study were to review existing school-based interventions designed to prevent childhood and adolescent obesity that were published between 1999 and 2004 and suggest ways of enhancing these interventions. It was decided to focus on interventions carried out in general population of children and adolescents that had a curricular component.

Methods

In order to collect the materials for the study, a search of CINAHL, ERIC and MEDLINE databases was carried out for the time period 1999–2004. The criteria for inclusion of the studies were: (i) publication in English language; (ii) publication between 1999 and 2004 (however, also included were any previous studies that were published in the specified time period); (iii) location of study either in United States or United Kingdom; (iv) focus on general population as opposed to overweight or obese children; and (v) having an explicit school-based curriculum for prevention of obesity. Exclusion criteria were publications in languages other than English, publications prior to 1998 (unless they were related to publications in the time period of 1999–2004), studies conducted outside of United States and United Kingdom, and studies that focused solely on overweight/obese children or adolescents. A total of 11 studies met the criteria.

Results

Schools are an important avenue for delivery of programmes. Children spend many hours in school, and PE classes are an important channel through which important behaviour change to reduce childhood obesity can be addressed (19,20). School-based interventions also have the potential for establishing healthy dietary and exercise patterns that may persist in adulthood and reduce chronic disease risk (21). School-based programmes are also cost-effective. An econometric analysis of a school-based obesity prevention programme, *Planet Health*, found that the approach of programming in schools can be cost-effective (22). Hence, the Institute of Medicine in its *Preventing Childhood Obesity: Health in the Balance* report (8) recommends that schools should provide a consistent environment that is conducive to healthful eating behaviours and regular physical activity. Low-income communities are becoming particularly vulnerable to increases in prevalence of overweight (23). These sections are often neglected in terms of health education programming. Further behaviour change is also more complicated in lower-socioeconomic sections of the community. Therefore, more programmes are needed for these sections of the community.

Several school-based interventions have been designed for preventing and treating childhood obesity. Story (24) reviewed all such interventions published between 1966 and 1996. She found that majority of these interventions were for secondary prevention or with students who were overweight or obese. Very few interventions had been carried out as primary prevention or population-based efforts that focused on whole population and aimed at preventing the onset of obesity. Almost all of the interventions focused on addressing both physical activity and nutrition components. She found that secondary interventions aimed at younger children were more successful than those with adolescents. She found that very few studies had follow-up data of at least 6 months. She recommended developing a comprehensive, integrated model for obesity prevention consisting of school health instruction (curriculum), PE classes, school counselling and psychology programmes, school-site health promotion for faculty and staff, family and community linkages, nutrition environment of the school, school health services and school food service.

Since the publication of this review article, some other primary or population-based interventions have also been published. We were able to locate 11 such interventions that are discussed in this article and summarized in Table 1. These have been arranged according to the grade level.

The first such intervention is the study at the kindergarten level by Datar and Strum (25) who examined the effect of PE instruction time on body mass index (BMI). They examined data from a national sample of 9751 kindergarteners to compare the effect of an increase PE instruction time between kindergarten and first grade on the difference in BMI. It was found that an increase of one hour of PE time in first grade compared with the time in kindergarten reduced BMI among girls who were overweight or at risk for overweight in kindergarten (coefficient = –0.31, $P < 0.001$). However, no significant effect was found in overweight or at risk for overweight boys (coefficient = –0.07, $P = 0.25$) or for normal BMI boys (coefficient = 0.04, $P = 0.31$) and girls (coefficient = 0.01, $P = 0.80$). The authors concluded that PE programmes in schools

Table 1 Summary of school-based curricular interventions

Study/grade/age/year	Theory	Intervention	Duration	Major findings
PE time (25) Kindergarten 5–6 years 1998–1999	No known theory	Increase physical education instruction time	One academic year	Reduced BMI in overweight girls (coefficient = –0.31, $P < 0.001$) No change in overweight or at-risk boys or for normal BMI boys and girls
Be Smart (26) 1st–2nd grade 5–7 years 2000–2001	Social cognitive theory (27)	Healthy nutrition Promote physical activity	4 school terms (14 months)	Improvement in nutrition knowledge ($P < 0.01$) Improvement in fruit ($P < 0.01$)/vegetable intake ($P < 0.05$) No significant change in overweight or obesity
APPLES (28,29) 2nd–4th grade 7–11 years 1996–1997	No known theory	Teacher training Modification of school meals Development of action plans Physical education Tuck shops Playground activities	One academic year	No change in BMI Vegetable consumption higher (0.3 portions d^{-1}) No change in physical activity
Stanford GEMS (30) 2nd–4th grade 8–10 years 2001	Social cognitive theory (27)	After-school dance Reduction of TV	Dance: 5 days per week × 3 months Home intervention: 5 lessons	Lowered BMI (–0.32 kg m^{-2}), waist (–0.63 cm), PE activity (55.1 counts min^{-1}), reduced TV (–4.96 h $week^{-1}$), less concern about weight (d = 0.60), improved grades (d = 0.51)
James' study (31) 2nd–5th grade 7–11 years 2001–2002	No known theory	Reduce consumption of carbonated drinks	One-hour session for each class each term for one year	Carbonated drinks decreased in the intervention group (by 0.6 glasses) The percentage of overweight and obese children also decreased in the intervention group (by 0.2%)

Table 1 *Continued*

Study/grade/age/year	Theory	Intervention	Duration	Major findings
Robinson's study (32) 3rd–4th grade 8–10 years 1996–1997	Social cognitive theory (27)	To reduce TV, videotape video game use	18 lesson, 6 month classroom curriculum	BMI (–0.45 kg m^{-2}), triceps skin-fold thickness (–1.47 mm), waist circumference (–2.30 cm) decreased Decreased TV viewing (–4.29 h $week^{-1}$)
Pathways Study (33–38) 3rd–5th grade (American Indian) 8–11 years 1997–1998	Social cognitive theory (27)	Classroom curriculum Physical activity Family involvement Food service modifications	2, 45-min lessons × 12 weeks	No significant reduction in body fat Knowledge ($P < 0.001$), attitudes ($P < 0.05$), and behaviours ($P < 0.001$) were positively and significantly changed
Project SPARK (39–41) 4th–5th grade 9–11 years 1990–1991	Self-management	Physical activity in & out of school Self-management curriculum	PE classes: 3 days a week × 36 weeks Self-management programme: 30 min × 32 sessions for each grade	PE activities increased at school (15–22 min; $P < 0.001$) Girls showed improvement in abdominal strength & endurance ($P < 0.001$) & cardiorespiratory ($P < 0.001$)
Planet Health (22,42–44) 6th–8th grade 12–14 years 1995–1997	Social cognitive theory (27)	Increasing physical activity Decreasing TV viewing Increasing fruit & vegetables Moderating fat intake	32 classroom lessons (integrated in language arts, math, science & social studies)	Reduced obesity in girls (odds ratio = 0.47) Increased fruit & vegetable intake ($P < 0.05$) Reduced TV watching ($P < 0.05$)
Frenn's study (45) 6th–8th grade 12–17 years 2000–2001	Pender's health promotion model (46) Transtheoretical Model (47)	Control fat in diet Increase physical activity	4 classroom sessions	Post-test percentage fat in food was significantly less ($t = 2.06$, $P = 0.04$) Duration of exercise was higher ($t = 2.925$, $P = 0.004$)
New Moves (48) 9th–12th grade (Girls only) 14–17 years 2000–2001	Social cognitive theory (27)	Physical activity TV viewing Fruit/vegetable intake Weight control behaviours	16 weeks	Majority of outcomes were not significant Girls in intervention progressed in stage of change for physical activity ($P = 0.004$)

APPLES, Active Programme Promoting Lifestyle Education in School; BMI, body mass index; PE, physical education; SPARK, Sports, Play, and Active Recreation for Kids.

need to be expanded and may be effective intervention for combating obesity in early years especially among girls.

A second school-based intervention from Britain carried out in 5–7-year-old children (first and second grades) known as '*Be Smart*' was implemented for 20 weeks over a period of 14 months (26). The intervention was based on social cognitive theory (27). The intervention was able to demonstrate improvement in nutrition knowledge ($P < 0.01$), fruit ($P < 0.01$) and vegetable intake ($P < 0.05$), but no significant changes in overweight and obesity.

Another British intervention is the *APPLES* (*Active Programme Promoting Lifestyles Education in School*) which has multiple components comprising of teacher training, modification of school meals, development of school action plans targeting the curriculum, PE, snack shops and playground activities (28,29). The programme was implemented in 10 primary schools (second through fourth grade; 7–11-year-olds) with 634 children and it was found that the programme had high degree of implementation. The intervention was also evaluated for impact in a group randomized controlled trial and it was found that there was no change on BMI, vegetable consumption was found to be higher in the intervention group children (0.3 portions d^{-1}, 95% CI: 0.2–0.4) with lower fruit consumption in obese children (–1.0 portions d^{-1}, 95% CI: –1.8 to –0.2), and no change in physical activity behaviour was found.

The fourth intervention is the *Stanford GEMS Pilot Study* that was designed to test the efficacy of an after-school dance intervention along with reduction of televi-

sion viewing among African–American girls (30). The intervention was 12 weeks in length and was based on Bandura's social cognitive model (27). It utilized a randomized controlled trial with 61 8–10-year-old African–American girls and their parents. The treatment intervention consisted of after-school dance classes at three community centres, and a five-lesson intervention delivered at home for reducing television and video watching. The control intervention consisted of distributing newsletters and delivering health education lectures. It was found that treatment group had lower BMI (adjusted difference = –0.32 kg m^{-2}; 95% CI: –0.77, 0.12), lower waist circumference (adjusted difference = –0.63 cm, 95% CI: –1.92, 0.67, d = 0.25), increased after-school physical activity (adjusted difference = 55.1 counts min^{-1}, 95% CI –115.6, 225.8), reduced television viewing (adjusted difference = –4.96 h $week^{-1}$, 95% CI: –11.41, 1.49, d = 0.40), less concern about weight (d = 0.60, $P = 0.03$) and improved grades (d = 0.51, $P = 0.07$). On the whole, the intervention was found to be feasible, efficacious and acceptable in the community.

The fifth intervention is the British study aimed at reducing consumption of carbonated drinks to prevent excessive weight gain in children (31). The intervention was carried out in second through fifth graders (7–11-year-olds). The intervention included 1-h session for each class each term that emphasized the message of discouraging the consumption of 'fizzy' drinks, and benefits of doing so. Teachers reiterated the messages and a music competition, art presentations, web site and a quiz were organized along the theme. In a cluster randomized controlled trial it was found that consumption of carbonated drinks decreased (0.6 glasses with average glass size of 250 mL) in the intervention group where as it increased in the control group (by 0.2 glasses). Likewise at 12 months the percentage of overweight and obese children also decreased in the intervention group (by 0.2%) where as it increased in the control group (by 7.6%).

The sixth intervention has been carried out in third and fourth grades with 8–10-year-olds. Robinson (32) developed and tested a 18-lesson, 6-month classroom intervention based on social cognitive theory (27) to reduce television, videotape and video game use. All third and fourth grade classrooms in two public schools in the same school district were chosen to participate and one school was randomly chosen to implement the programme. It was found that BMI (adjusted difference = –0.45 kg m^{-2}, 95% CI: –0.73 to –0.17, $P = 0.002$), triceps skin-fold thickness (adjusted difference = –1.47 mm, 95% CI: –2.41 to –0.54, $P = 0.002$), waist circumference (adjusted difference = –2.30 cm, 95% CI: –3.27 to –1.33, $P < 0.001$), and waist-to-hip ratio (adjusted difference = –0.02, 95% CI: –0.03 to –0.01, $P < 0.001$) decreased significantly in the intervention group over time as compared with control group. There were also statistically significant decreases in children's reported television watching and meals taken in front of television. There were no changes in high-fat food intake, moderate to vigorous physical activity and cardiorespiratory fitness. Thus the intervention to limit television viewing was found to be efficacious in impacting childhood obesity.

The seventh intervention has been carried out in third to fifth grade American Indian students (8–11-year-olds). *Pathways Study* (33) was designed to evaluate the effectiveness of a school-based, multi-component intervention for reducing percentage body fat in American Indian elementary school children in Arizona, South Dakota and New Mexico. The study was a randomized, controlled, school-based trial involving 1704 children in 41 schools and was conducted over a period of 3 years from third to fifth grades. The intervention was based on social cognitive theory (27) and American Indian culture and practices. It consisted of four components: classroom curriculum, food service modifications, physical activity and family involvement. Students received about 93% of the classroom lessons (34). No significant reduction in percentage body fat was noted after the intervention. Twenty-four hour dietary recall demonstrated a significant reduction in percentage of energy from fat but it was not confirmed by direct observation. Knowledge ($P < 0.001$), attitudes ($P < 0.05$) and behaviours ($P < 0.001$) were positively and significantly changed by the intervention. The intervention demonstrated that curricular changes can improve knowledge and behaviours of elementary school children (35). Likewise school food service staff can be trained to make effective changes in school menus. The pathways intervention was successful in reducing the intake of percentage calories from fat and saturated fat at school lunch and throughout the day (36). In terms of physical activity no significant differences were found (37). Teachers, food service managers and PE instructors were supportive of the *Pathways* intervention (38). But in order to effect the percentage body fat, longer interventions may be needed.

The eighth intervention is *Project SPARK* (*Sports, Play, and Active Recreation for Kids*) (39–41) which is a comprehensive curriculum for fourth and fifth grades designed to promote physical activity in and out of school. It was implemented in 1990–1991 but has also been published in the time period of 1999 and 2004, and was thus included in the analysis. In a professional development programme the teachers are trained to implement the curricula. The classes are taught for a minimum of 3 days a week throughout the school year (36 weeks). The curriculum has three components: health-fitness segment includes activities such as aerobic dance, running games, etc.; sport-fitness segment includes sports such as soccer, basketball, etc.; and self-management programme that includes emphasis on behaviour change skills. In a randomized controlled trial involv-

ing seven schools where all fourth and fifth grade classes were assigned to traditional PE (control), PE by trained classroom teachers and PE by PE specialists (40). The intervention found that intervention group increased PE activities during PE classes in specialist-led classes (40 min) and teacher-led classes (33 min) as opposed to control classes led by traditional teachers (18 min, $P < 0.001$). However this time was not increased outside of school. Girls showed improvement in two out of five fitness measures, namely, mile-run time and sit-up test. There were no changes in pull-ups, skin-folds or sit and reach. Further it was found that health-related PE did not interfere with academic achievement and may have favourable effects on students' academic achievement (41).

The ninth intervention is *Planet Health* which is an integrated, interdisciplinary middle school curriculum that focuses on four health goals of increasing physical activity, decreasing television viewing, improving diet through increased vegetable and fruit intake, and moderating fat intake (42–44). It has been implemented in sixth through eighth grade with students in the ages 12–17. In a randomized controlled trial, *Planet Health* was found to reduce obesity prevalence (odds ratio = 0.47, 95% CI: 0.24–0.93, $P = 0.03$), increase fruit and vegetable consumption in girls ($P < 0.05$). It reduced sedentary behaviour of television watching and increased knowledge on curricular topics among both girls and boys ($P < 0.05$). The intervention was also found to be feasible and acceptable when implemented with 129 teachers in six public schools (44).

The 10th intervention is by Frenn and colleagues (45) who designed an intervention to reduce fat intake in diet and increase physical activity in middle school children. The intervention was based on the Pender's (46) health promotion model and transtheoretical model (47). Experimental group ($n = 60$) receiving four classroom sessions was compared with the control group ($n = 57$) that received the usual classroom education. It was found that post-test percentage fat in food was significantly less for the intervention group as compared with the control group ($t = 2.06$, d.f. = 115, $P = 0.04$). Also the duration of exercise was significantly higher for the intervention group than the control group ($t = 2.925$, d.f. = 81, $P = 0.004$). The study did not look at body fat or BMI. The results of the study support use of a theoretical approach in changing obesity-related behaviours in childhood.

The final intervention was '*New Moves*' which is a school-based obesity prevention programme for adolescent girls that was implemented as a multi-component, girls-only, high school PE class (48). The intervention group ($n = 89$) was compared with the randomly assigned control group ($n = 112$). The intervention was based on social cognitive theory (27). Data were collected at baseline, post-intervention, and 8-month follow-up to assess impact on physical activity stage of change, physical activity outside of PE classes, hours watching TV, fruits/vegetables intake, soda pop intake, breakfast consumption in past week, fast food consumption in past week, weight control behaviours, binge eating, BMI, self-acceptance, athletic competence, physical appearance, self-worth, media internalization, benefits of physical activity, benefits of healthful eating, enjoyment of physical activity, self-efficacy to be physically active, parent support, peer support and staff support. In addition, interviews with school staff, parent surveys and participant interviews were also conducted. The programme received high satisfaction rating by participants. For the majority of outcome variables including BMI differences between intervention and control groups were not significant. At post-intervention in control groups 20% of the girls progressed in their stage of physical activity and 24% regressed while in the intervention group 31% progressed and 19% regressed. At follow-up the percentage changes in stage were unchanged in control schools while in intervention schools 38% progressed while only 11% regressed. The chief utility of the programme is its utilization of exiting PE classes and being only girls which may be attractive to some girls who face barriers in co-ed classes.

Discussion

The purpose of this article was to review population-based interventions for preventing childhood and adolescent obesity carried out in school settings published between 1999 and 2004. Based on a review of these interventions it is evident that there is a need for more population-based prevention programmes since there were only a total of 11 interventions that were found and the problem of obesity in childhood is quite enormous. The grade range of the interventions was from kindergarten, primary grades, middle school to ninth to 10th grade in high school. Seven out of 11 interventions (64%) were in the elementary school which makes sense because the dietary and physical activity behaviours are beginning to get formed in these years and interventions designed to alter modifiable physical activity and nutrition behaviours at this juncture can go a long way. Further the results from the interventions carried out in upper elementary and lower middle school years such as James study (31), Robinson study (32), *Pathways Study* (33–38), *Project SPARK* (39–41), *Planet Health* (42–44) and Frenn's study (45) indicate that targeting interventions in upper elementary and lower middle school years are most helpful.

Most of these interventions (55%) targeted both physical activity and nutrition behaviours although there were some interventions (27%) that focused on only one dimension such as TV watching or restricting drinking of carbonated drinks or increasing PE time in the school. While multifaceted, comprehensive programmes are beneficial, single-

component programmes also show promise such as the British study reducing carbonated drinks (31). However, it cannot be clearly said that single-component interventions are any better than multi-component interventions. Hence, it is essential to invest in both multi-component and single-component programmes.

Most of the interventions (73%) were based on some behavioural theory and the most popular theory was social cognitive theory (27). Social cognitive theory has been tested with a number of behaviours and number of target populations (49). It is particularly helpful in school-based settings and must be reified and improved further. Very few interventions have measured and documented changes in behavioural constructs of the theory they have reified. In order to improve a theory it is important to find out which components or constructs of a theory are working and to what extent. Researchers and evaluators must make effort to develop psychometrically robust instruments that measure the changes in constructs of the theory that is being used in the intervention.

In terms of the duration, two of the interventions (18%) were brief: four classroom sessions and 1-h session per class term per year. Three (27%) were middle range in length: 12 weeks, 3 months and 16 weeks. While remaining interventions (55%) were long: 32 lessons, 36 weeks, 6 months, and one academic year. The results were not necessarily linked with the length of the intervention. Generally speaking, interventions that have not used a behavioural theory have been longer in duration. If behavioural theories are reified adequately, the time of the interventions can be reduced and more meaningful interventions designed. From a practical point of view, middle range interventions work well and future interventions must aim at developing such interventions.

Some interventions (45%) have used out of school activities and involvement of parents. Both these approaches seem promising and must be systematically developed and tested. One intervention (48) has focused on implementing the intervention for girls only. While there seem to be some advantages of this approach, the results of the programme have not been very encouraging to justify a gender-specific intervention.

Most of the interventions (91%) have focused on individual level behaviour change approaches and few have tried to address broader policy and environmental level changes. Most of the interventions have focused on short-term changes right after the intervention and it is essential to have measures at least at 6 months after the intervention to see for the retention of behaviour change. On the whole, interventions have resulted in modest changes in behaviours and mixed results with indicators of obesity thereby necessitating more effective use of theoretical approaches. TV watching seems to be the most modifiable behaviour, followed by physical activity and nutrition behaviours. Most programmes have used multiple components and often it is not discernible which component works and to what extent. In multifaceted programmes antecedents of behaviours are typically not studied. The final outcome measures such as lowered BMI, triceps skin-fold thickness and waist circumference have not been measured by all studies and must be measured after sufficient dose of intervention and duration of time.

In terms of the person implementing the intervention, 10 out of 11 (91%) interventions utilized existing teachers mostly with additional training. This seems to be the most feasible and practical approach. Only two interventions used specialists: *Project SPARK* (39–41) (in addition to the teachers) and Stanford GEMS (30) (exclusively). Clearly the use of specialists improved the quality of implementation by adding novelty effect and additional resources. In *Project SPARK* (39–41) the specialist-led group was able to increase PE activities during PE classes more than teacher-led classes. However, it may not always be practically feasible to include external health and PE specialists because of fiscal, legal and other constraints.

In terms of measuring the quality of intervention implementation, seven interventions out of 11 (64%) made varying levels of documentation. Most of those reporting the quality of implementation measured satisfaction among children, teachers and parents. Very few interventions documented the degree of fidelity in implementation of the planned curriculum. Documenting aspects of process evaluation are equally important and are precursors to changes in impact and outcome indicators (50). These must be reported by all interventions.

Recommendations for enhancing school-based interventions

Population-based interventions directed towards addressing childhood and adolescent obesity prevention should target both physical activity and nutrition behaviours. Reducing TV watching has also been found to be a modifiable behaviour and must be addressed in future interventions aimed at decreasing childhood and adolescent obesity. In nutrition behaviours aspects for increased fruit and vegetable consumption, decreased fat intake, decreased consumption of carbonated drinks, adequate consumption of water and restricting portion sizes are important aspects.

There is need for all interventions to be based on behavioural theories. Further interventions must clearly measure the constructs they have reified before and after the intervention which will give greater confidence in the intervention and the link the results to the theoretical approach. There is need to develop psychometrically robust instruments that are able to measure the changes in constructs of various behavioural theories being used by intervention researchers.

It has been found that even small amounts of increase in PE time are helpful in reducing childhood obesity (25). All interventions must try to utilize existing PE programmes in the school system and either enhance their effectiveness by incorporating a theoretical approach or involving the PE teachers to deliver or supplement the messages they are trying to convey.

For intervention activities, there is need to support individuals to make behaviour changes in their diets and exercise habits. At the same time there is need to change both policies and environments so that these are supportive of entire communities in eating healthy foods and enjoying regular physical activity (51). Hence curricular programmes need to be supplemented with health promotion interventions that change policies and environments.

Conflict of Interest Statement

No conflict of interest was declared.

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