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International school-based interventions for preventing obesity in children

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Summary

The purpose of this article was to review international (excluding the United States) school-based interventions for preventing obesity in children published between 1999 and 2005. A total of 21 such interventions were found from Australia (1), Austria (1), Canada (1), Chile (1), France (1), Germany (3), Greece (1), New Zealand (1), Norway (1), Singapore (1) and the United Kingdom (9). The grade range of these interventions was from pre-school to high school with the majority (17) from elementary schools. Nine of these interventions targeted nutrition behaviours followed by seven aiming to modify both physical activity and nutrition behaviours. Only five interventions in international settings were based on any explicit behavioural theory which is different than the interventions developed in the United States. Majority of the interventions (9) were one academic year long. It can be speculated that if the interventions are behavioural theory-based, then the intervention length can be shortened. All interventions that documented parental involvement successfully influenced obesity indices. Most interventions (16) focused on individual-level behaviour change approaches. Most published interventions (16) used experimental designs with at least 1-year follow-up. Recommendations from international settings for enhancing the effectiveness of school-based childhood obesity interventions are presented.

Keywords: Children, nutrition, physical activity, schools.

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Introduction

Globally, obesity has reached epidemic proportions with over 1 billion people classified as overweight and of those at least 30% are obese (1). Since, approximately one-sixth of the world population is struggling with overweight; therefore, it is considered a public health crisis that contributes in a major way to a number of chronic diseases, disability and premature mortality (2). Obesity in childhood and adolescence has also increased at a dramatic pace over the last few years all over the world in industrialized, as well as, many developing countries (3–5). Overall, 10% of the school-aged children in the world are overweight (6). For example, in Japan (7), between 1974 and 1993 obesity in 6–14-year-olds doubled from 5% to 10%; in England (8), between 1984 and 1998, among 7–14-year-olds obesity increased from 8% to 20%; in Spain (9), from 1985 to 1995 among 6–7-year-olds overweight children increased from 23% to 35%; in France (10), from 1992 to 1996 obesity in 5–12-year-olds increased from 10% to 14%; in Greece (11), in 2000, the overweight rates were found to be 22% and obesity rates 4%; in Australia (12), between 1985 and 1997, the prevalence of childhood obesity trebled with present rates in children (13) between 27% and 30%; in Thailand, in 2000, prevalence of childhood obesity was found to be between 11% (14) and 14% (15); and, in India, in one study 10% of boys and 12% of girls were found to be overweight with 5% of boys and 6% of girls obese (16). In some countries in some subgroups, the rate of obesity is very high. For example, in New Zealand Pacific children, one study (17) found obesity in 3–7-year-olds to be as high as 34–49%. Globally, an estimated 22 million children under 5 years of age are estimated to be overweight (1). Obesity accounts for 2–6% of the total healthcare costs in several developed countries with the costs being up to 7% in some countries (1). Globally, obesity accounts for more

than 15 million disability adjusted life years and 1–1.5 million years of life lost per annum (18). It needs to be kept in mind that intercountry comparisons are often unreliable because of differing definitions and measures used in different countries.

Childhood overweight and obesity are particularly harmful as these persist in the adolescence and adulthood (19,20). The Bogalusa Heart Study (21) performed in the United States found that by age of 10 years, 60% of overweight children had at least one biochemical or clinical cardiovascular risk factor and 25% had more than two. Childhood obesity is associated with several short-term medical consequences such as adverse blood lipid profile, altered glucose metabolism, obstructive sleep apnea and long-term effects such as higher risk of hypertension, diabetes, cardiovascular disease, gall bladder disease and osteoarthritis in adulthood (20). 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 (22).

There are differing standards for defining overweight and obesity around the world (23). Body mass index (BMI), which is measured as the weight in kilograms divided by the square of the height in metres (kg m^{-2}), is often used for defining overweight (BMI $\geq$ 25 kg m^{-2}) and obesity (BMI $\geq$ 30 kg m^{-2}) in the United States (24). However, for different populations around the world, the use of these BMI cut-offs has been questioned as these do not correlate well with per cent body fat and other risks such as heart disease, hypertension, glucose intolerance and lipid profiles (25). As a result, for example, recommendations for Asians are lower than Western populations and for overweight are BMI $\geq$ 23 kg m^{-2} and for obesity BMI $\geq$ 25 kg m^{-2} (26). For children, Centers for Disease Control and Prevention has defined 'overweight' as at or above the 95th percentile of BMI for age and 'at-risk for overweight' as between 85th to 95th percentile of BMI for age (27). In Europe, 'overweight' is classified as at or above the 85th percentile and 'obesity' at or above the 95th percentile (28). In addition to BMI, there are other measures of adiposity such as waist-to-hip ratio, waist circumference (WC), skin fold thickness (subscapular, triceps, suprailiac, abdominal and their sum or ratios), fat mass determined with bioimpedance and others that are measured by different researchers (29).

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 socio-economic influences. For a large majority of individuals, overweight and obesity often result from excess energy consumption and/or inadequate physical activity (30). 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 (31). Childhood is considered a priority population for prevention programmes because (i) it is easier to lose weight in childhood than in adulthood and (ii) it is easier to implement prevention programmes in school settings (32). However, it also needs to be emphasized that weight stability in years of growth is a better approach.

The interventions for childhood obesity can be directed at the whole community (universal prevention, e.g. school-based interventions), or at high risk individuals (selective prevention, e.g. children of obese parents), or at persons with the problem (secondary prevention, e.g. with overweight and obese children) (33). This study focused on universal prevention interventions performed in school settings for all children. Maximum number of interventions have been performed and tested in the United States (34–36). However, a comparison of US interventions with interventions in other countries does not exist. The influence of the United States on designing health education interventions is often perceived as amphoteric (partly one way and partly another way). Some scholars believe that the theories and models developed in the United States are gold standards and most international programmes are based on those models. While other scholars believe that the United States borrows concepts and ideas from other countries and reshapes those to develop models. In order to qualitatively control for the influence of the United States, these studies were excluded from the present analysis. However, the influence of US models where applicable has been pointed out. Such a review will help in discerning how interventions in other countries are similar to or different from those in the United States. Also as the population in the United States is becoming more and more diverse, so such a review will help in developing interventions for high-risk subgroups of populations who have their national origin in other countries. Hence, the purpose of this review was to summarize the various obesity prevention interventions performed in international settings (other than the United States) for children in the ages 3–18 years.

Methodology

In order to collect the materials for the study, a search of CINAHL (Cumulative Index to Nursing and Allied Health Literature), ERIC (Education Resources Information Center), and MEDLINE (National Library of Medicine) databases was performed for the time period 1999–2005. The criteria for inclusion of the studies were (i) publication in English language; (ii) publication date between 1999 and 2005; (iii) location of the study outside the United States and (iv) focus on general population of children in school

settings (including pre-school) for children between 3 and 18 years old. Exclusion criteria were publications in languages other than English, publications prior to 1999 (the studies conducted prior to 1999 but published in or after 1999 were included), studies conducted in the United States, studies outside school settings (such as in hospitals or clinics), studies published in non-peer-reviewed journals and studies that focused solely on overweight/obese children or adolescents. Search terms used were 'obesity', 'overweight', 'children', 'childhood', 'prevention', 'schools' singly and in combination ('childhood and obesity', 'childhood and/or obesity or overweight and prevention'). A total of 12 studies met the criteria.

Results

The interventions have been arranged in ascending order of the age group for which these have been developed and have been summarized in Table 1. The first intervention described is called the *Movement and Activity Glasgow Intervention in Children* in 3–4-year-old pre-schoolers who attend nursery schools in the United Kingdom (36). Detailed data from this intervention are still not available but they have been described in a review article published in 2003 with pilot study data (36). Using a randomized controlled design, 220 children were randomized to the intervention group and 220 to the control group. Measurements for BMI, physical activity by accelerometry, body fat distribution, body composition, blood pressure and motor skills were recorded at baseline, after 6 months and after 1 year. Pilot data from 60 children at 12 weeks revealed significant improvement ($P < 0.001$) in physical activity (40% increase in accelerometry output on days the intervention was delivered and 29% increase on days it was not delivered) and improvement in motor skills ($P < 0.01$). The process evaluation results in terms of ease of implementation and acceptance by nursery staff and students were also found to be positive.

The second intervention was the National School Fruit Scheme implemented between 2000 and 2002 in the United Kingdom (37). Children were provided one free piece of fruit every day. It was found that median fruit consumption in infants receiving free fruit was 117 g d^{-1} compared with 67 g d^{-1} for those not receiving ($P < 0.0001$).

The third intervention was a school-based intervention (38) also from the United Kingdom conducted with 5–7-year-old children (first and second grades) known as 'Be Smart'. This was based on social cognitive theory (39). The intervention aimed at increasing the expectations and expectancies of the physical activity and nutrition behaviours, provided opportunity to taste healthy foods, provided incentives such as verbal praise and small prizes, developed practical skills to build self-efficacy and worked with parents to remove barriers to desired healthy behaviours. The intervention was able to demonstrate improvement in nutrition knowledge ($P < 0.01$), fruit consumption ($P < 0.01$) and vegetable intake ($P < 0.05$) but no significant changes in overweight and obesity.

The fourth intervention was a German intervention called *Prevention Education Program* (PEP) which began in 1994 in Nuremberg and data from this intervention are still being collected (40–42). First grade children (5–7-year-olds) from 37 schools (22 control and 15 experimental) and their families (1740 first graders, 3046 parents, 1521 siblings) were recruited. Baseline data showed a high prevalence of obesity in adults (42%) and children (19%) along with elevated risk for other cardiovascular disease risk factors. More long-term results are expected from this project.

The fifth intervention was a German project, *Kiel Obesity Prevention Study* (KOPS) that was initiated in 1996 and is scheduled to run until 2009 (43). Between 1996 and 1999, the project recruited 2440 children in the ages 5–7 years. The study implemented an intervention that included developing knowledge, self-monitoring, increasing self-esteem and building personal autonomy. Short-term effects of the intervention at 3 months demonstrated increase in nutrition knowledge, increase in daily physical activities and decrease in TV watching ($P < 0.05$). One-year follow-up showed that median triceps skinfold thickness in intervention schools increased from 10.9 mm to 11.3 mm while in control groups this increase was from 10.7 mm to 13.0 mm ($P < 0.01$). Likewise percentage fat mass of overweight children increased only 0.4% in intervention schools as compared with 3.6% in control schools ($P < 0.05$). More long-term results are expected from this project (33).

The sixth intervention was a simple intervention performed in the United Kingdom that provided fluorescent markings in the playground (44). It was found that moderate to vigorous physical activity was increased among children at the school where the intervention was provided.

The seventh intervention was a Peer Modelling and Rewards intervention performed with 5–11-year-olds in the United Kingdom (45). It was based on the theory of rewarding behaviour and providing modelling through a video of peer role models who ate fruits and vegetables. As a result of the programme, in comparison with the control group, fruit and vegetable consumption at lunchtime ($P < 0.0001$), at snack time ($P < 0.0001$) and at home ($P < 0.05$) increased significantly.

The eighth intervention was a German intervention called *StEP TWO programme* which was implemented in primary schools in children with ages between 7 and 9 years (46). In step one of the intervention, health education and physical activity were taught by regular teachers during the normal school day. Children who were identified as overweight and obese were given the step two

Table 1 Summary of international school-based interventions for prevention of overweight and obesity

Study/grade/age/year/country	Theory	Intervention	Duration	Major findings
Movement and Activity Glasgow Intervention in Children (36) Pre-school 3–4-year-olds 2002–ongoing The United Kingdom	No known theory	• Increase activity levels • Improve motor skills	24-week programme (thrice a week)	• Improvement in physical activity (29–40%, $P < 0.001$) • Improvement in motor skills ($P < 0.01$) • High ease of implementation and high acceptance • Change in overweight/obesity not measured
National School Fruit Scheme (37) Pre-school and kindergarten 4–6-year-olds 2000–2002 The United Kingdom	No known theory	• Providing one free piece of fruit each day to children	Two academic years	• Median total fruit consumption in infants receiving free fruit was 117 g d^{-1} compared with 67 g d^{-1} in those not receiving ($P < 0.001$) • Adiposity indices not measured
Be smart (38) 1st–2nd grade 5–7-year-olds 2000–2001 The United Kingdom	Social cognitive theory (39)	• Healthy nutrition • Promote physical activity	Four 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/obesity
Prevention Education Program (40–42) 1st grade 5–7-year-olds 1994–ongoing Germany	No known theory	• Parents and children • Medical and dietary advice • Health curriculum on heart risk factors, diet and physical activity • Group sessions	• Advice once a year • 40 lessons $year^{-1}$ • Biweekly group sessions × 1 year	• Baseline high prevalence of obesity in adults (42%) and children (19%) • Results awaited
Kiel Obesity Prevention Study (43) 1st grade 5–7-year-olds 1996–ongoing Germany	No known theory	• Knowledge • Self-monitoring • Self-esteem • Personal autonomy • Eating fruits/vegetables • At least 1-h activity • <1 h TV d^{-1} • Face-to-face counselling	• 8-h nutrition education • Three to five home visits for counselling	• Increase in nutrition knowledge ($P < 0.05$) • Increase in daily physical activities ($P < 0.05$) • Decrease in TV watching ($P < 0.05$) • Less increase in triceps skinfold thickness ($P < 0.01$) • Less increase in % fat mass ($P < 0.05$)
Playground markings study (44) 1st grade 5–7-year-olds Published in 2000 The United Kingdom	No known theory	• Fluorescent markings of the playground	• 8 weeks (measurements 4 weeks before and 4 weeks after the markings)	• Moderate to vigorous activity significantly increased in experimental group ($P < 0.05$) • Adiposity indices not measured
Peer Modelling and Rewards (45) 1st grade 5–11-year-olds Published in 2005 The United Kingdom	Rewarding behaviour and modelling	• For 16 days children watched video (Food Dudes) in which peer model ate fruits and vegetables • Also given rewards for eating fruits/vegetables	5 months	• Compared with control, lunchtime ($P < 0.001$), snacktime ($P < 0.001$), and at-home ($P < 0.05$) fruits and vegetables intake increased • Adiposity indices not measured
StEP TWO programme (46) Primary	No known theory	• Step 1: health education and physical activity by regular teachers	One academic year	• Increase in BMI was lower ($P = 0.042$) • Systolic blood pressure was lower ($P = 0.028$)

Table 1 *Continued*

Study/grade/age/year/country	Theory	Intervention	Duration	Major findings
7–9-year-olds 2003–2004 Germany		• Step 2: special cooked meals and 60–90-min physical activity with overweight and obese children • Parental involvement for six evenings		
Switch-play (77) 5th grade 10-year-olds 2002–2003 Australia	• Social cognitive theory (39) • Behavioural choice theory (47,48) • Ecological theory (49)	• First group (BM): behaviour modification • Second group (FMS): fundamental motor skills • Third group: BM + FMS • Fourth group: control (usual classroom sessions)	19 sessions (40–50 min) × 3 school terms	• High attendance rates (88%) • Moderate at-home task completion (57–62%) • High in-class task completion (92%) • Two-thirds of kids self-reported switching off TV • More results awaited
APPLES (53,54) 2nd–4th grade 7–11-year-olds 1996–1997 The United Kingdom	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
James's study (55) 2nd–5th grade 7–11-year-olds 2001–2002 The United Kingdom	No known theory	• Reduce consumption of carbonated drinks	One hour session for each class each term for 1 year	• Carbonated drinks decreased (by 0.6 glass) in the intervention group • The percentage of overweight and obese children also decreased in the intervention group (by 0.2%)
Fruit tuck shops (56) Primary 5–14-year-olds 1999–2000 The United Kingdom	No known theory	• Set up and operate fruit tuck shops	One academic year	• Head teachers at 20 out of 23 schools felt that fruit tuck shops had been successful • Adiposity indices not measured
Cretan Health and Nutrition Education Programme (57–60) Grades 1–6 6–15-year-olds 1992–ongoing Greece	Social cognitive theory (39)	• Based on American: Know Your Body (61) Teacher delivered Physical education Nutrition Parental involvement	One academic year (13–17 h)	• Cholesterol decreased (–0.27 mmol L^{-1}) • Less BMI increase ($P < 0.05$) • Less increase in biceps skinfold ($P < 0.05$) • Increased leisure time physical activity (+281 min $week^{-1}$) • 4 years after the programme no differences: subgroup analyses being performed
Diet and Nutrition Intervention (62) Grades 1–8 5–15-year-olds 2002–2003 Chile	No known theory	• Nutrition education for children and parents • Healthier kiosks • Active recess • 90-min additional physical activity	One academic year	• Significant improvement in BMI and WC for boys ($P < 0.001$) but no change for girls • Significant improvement in fitness for boys and girls ($P < 0.001$)
PRESTO (63) Grade 1 10–12-year-olds Published in 2005 Austria	No known theory	• 11 health sessions • Multidisciplinary team: physician, psychologist, nutritionist, physical activity expert, teachers	One academic year	• Significant improvement in knowledge ($P < 0.0001$) (OR 3.38) and boys (OR 1.73) • No change in BMI at 14 weeks or 10 months

Table 1 *Continued*

Study/grade/age/year/country	Theory	Intervention	Duration	Major findings
ICAPS (64) First level 10–12-year-olds 2002–2003 France	• Social support • Environmental and personal determinants	• Education on physical activity • Opportunities for physical activity • Social support of parents, peers, PA instructors, teachers	6 months (ongoing)	• Leisure time physical activity significantly increased in girls (OR 3.38) and boys (OR 1.73) • Self-efficacy improved ($P < 0.05$) • Adiposity indices not measured
Pedometer Intervention Trial (65) High schools 11–12-year-olds 2002 New Zealand	No known theory	• 12 weeks' physical activity self-monitoring and educative programme • Two groups: one set step targets (PED), the other set minutes (MIN)	Adoption phase of 6 weeks with group sessions, 6 weeks maintenance phase with postcards	• PED group at post-test significant increase ($P = 0.03$, ES 0.13) in physical activity • No pre-, mid- or post-intervention changes in BMI
Trois-Rivieres Growth and Development Study (66–70) Primary school 12-year-olds (followed to 34 years) 1970s–1998 Canada	No known theory	• Daily physical education in primary school	6 years of regular PE	• No significant changes observed at age 34 between experimental and control groups for BMI, fitness indices and physical activity readiness
Norweigian School Fruit Programme (71) 7th grade 11–12-year-olds 2001–2002 Norway	No known theory	• Free fruit in three schools • Paid fruit in three schools • No fruit in three schools	One academic year	• Free fruit school had significantly higher intake of fruits and vegetables ($P < 0.001$) • Adiposity indices not measured
Cooled filtered water (72) Secondary schools 11–18-year-olds 2003 The United Kingdom	No known theory	• Provision of cooled filtered water with promotion	3 months	• Water consumption increased ($P < 0.05$) • No change in soft drink consumption • Adiposity indices not measured
Trim and Fit (73) K-12 5–18-year-olds 1992–2000 Singapore	No known theory	• Nutrition education integrated in curriculum • Restriction on selling high-fat foods and high-sugar drinks • Children encouraged to drink water • 'Trim and fat' awards annually to schools for meeting goals • Intensive follow-up of obese children	K-12 every year	• Between 1992 and 2000, obesity in 11–12-year-olds decreased • Between 1992 and 2000, obesity in 15–16-year-olds decreased from 16.6% to 14.6% from 15.5% to 13.1%

APPLES, Active Programme Promoting Lifestyles Education in School; BM, behavioural modification; BMI, body mass index; FMS, fundamental motor skills; WC, waist circumference.

which entailed providing specially cooked meals (comprising of vegetarian food, fruits and vegetables) and 60–90 min of physical activity (such as aerobic dance, endless relay, soccer, etc.). Parents were involved in six evenings. Data were collected from 1689 children of whom 7.3% were obese, 10.4% were overweight, 75.7% were normal-weight and 6.6% were underweight. The intervention children were compared with children in control schools. After the intervention, the increase in BMI was lower (P = 0.042) and systolic blood pressure was lower (P = 0.028) in the intervention group in comparison with the control group.

The ninth intervention is an Australian intervention called *Switch-Play* which was designed for 10-year-olds to reduce sedentary behaviour and increase physical activity (43). It utilized a cluster randomized trial with a 2×2 factorial design and collected data at baseline, post intervention, after 6 months and after 12 months from 397 fifth grade children from three Melbourne schools. The intervention was based on social cognitive theory (39), behavioural choice theory (47,48) and ecological theory (49). It was adapted from several American programmes: SPARK programme (50), Robinson's study (51) and Planet Health (52). Students were randomized by class to one of the four conditions: a behavioural modification (BM) group (n = 69) that had 19 sessions (40–50 min) aimed at decreasing TV time, a fundamental motor skills (FMS) group (n = 73) that had 19 sessions (for mastery of skills for running, throwing, dodging, striking, vertically jumping and kicking), a combined BM and FMS group (n = 90) that had skills from both groups and control (usual classroom lessons) group (n = 61). Process evaluation results indicated high attendance rates (88%), moderate at-home task completion (57–62%) and high in-class task completion (92%). Between 70% and 80% of parents who had participated in the intervention indicated they had heard of the intervention as opposed to 40% of parents in the control group. About two-thirds of the children in the BM group self-reported that they switched off the TV. Future results from this intervention are awaited.

The tenth intervention was an intervention performed in the United Kingdom called the *Active Programme Promoting Lifestyles Education in School* (APPLES) which has multiple components comprising of teacher training, modification of school meals, development of school action plans targeting the curriculum, physical education, snack shops and playground activities (53,54). 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. It was found that there was no change on BMI. However, 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), but no change in physical activity behaviour was found.

The eleventh intervention is an intervention performed by James and colleagues in the United Kingdom aimed at reducing consumption of carbonated drinks to prevent excessive weight gain in children (55). The intervention was performed with second through fifth graders (7–11-year-olds). The intervention included an hour session for each class each term that discouraged consumption of 'fizzy' drinks. Teachers reiterated the message and a music competition, art presentations, websites 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 glass with average glass size of 250 mL) in the intervention group where as it increased in the control group (by 0.2 glass). 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 twelfth intervention from the United Kingdom consisted of organizing fruit tuck shops (56). The intervention lasted one academic year. At the end, 20 out of 23 teachers felt that fruit tuck shops had been successful. Adiposity indices were not measured.

The thirteenth international intervention was from Greece called the *Cretan Health and Nutrition Education Programme* which was the first school-based health education intervention in the country and was started in 1992 with a duration of 6 years (57–60). The intervention was based on the American *Know Your Body* curriculum developed in the 1970s and 1980s (61) and was guided by social cognitive theory (39). The intervention was implemented in grades 1–6 (6–15-year-olds). A random sample of 24 intervention schools (602 students and their parents) was compared with a sample of 16 control schools (444 students and their parents). At the end of the 6-year period, it was found that total cholesterol improved significantly in the intervention group (–0.27 mmol L^{-1}) compared with the control group (–0.12 mmol L^{-1}); change in BMI was also favourable for the intervention group (+3.68 kg m^{-2}) compared with the control group (+4.28 kg m^{-2}); change in biceps skinfold was also favourable for the intervention group (+2.97) compared with control group (+4.47 mm); total energy intake was also favourable for the intervention group (+747.7 kJ) compared with the control group (+1534.7 kJ). The time devoted to leisure time physical activity also increased significantly more in the intervention group (+281 min $week^{-1}$) compared with the control group (+174 min $week^{-1}$) and cardiovascular run test performance was also higher in the intervention group (+2.5 stages) compared with control group (+1.2 stages). Four years after the intervention, BMI values did not differ in experimental and control groups. Further data analysis by subgroups is currently being undertaken.

The fourteenth intervention was the diet and nutrition intervention performed in grades 1–8 (5–15-year-olds) from Chile (62). Both physical activity and nutrition were targeted. Significant improvement in BMI and WC were noted for boys ($P < 0.01$) but not girls.

The fifteenth intervention is from Austria, a school-orientated project, called *PRESTO* (63). This was designed for the first grade classes (ages 10–12 years) to influence nutrition, physical activity and obesity. The project was implemented by an interdisciplinary team comprising of a physician, a psychologist, a nutritionist and an expert in physical activity and consisted of 11 health-related sessions of 1 h per week. In comparison with a control group ($n = 231$), the experimental group ($n = 260$) demonstrated statistically significant improvement in knowledge ($P < 0.0001$). However, there was no change in BMI for overweight children on either a short-term (14 weeks) or a long-term (10 months) basis.

The sixteenth intervention was from France and was called *Intervention Centered on Adolescents' Physical Activity and Sedentary Behaviour* (64). The intervention was based on modifying personal and environmental determinants including social support. After 6 months, the intervention was able to demonstrate significant improvement in physical activity and its antecedents ($P < 0.05$).

The seventeenth intervention is the Pedometer Intervention trial performed in New Zealand (65). Children were taught to monitor their steps using a pedometer. Significant increase in physical activity was found. However, there were no changes in BMI.

The eighteenth intervention was a long-term longitudinal study initiated in the 1970s with primary school students in Canada called the *Trois-Rivieres Growth and Development Study* which followed up 12-year-old primary school children who had completed 6 years of physical education in school to the age of 34 years (66–70). No significant changes in adiposity indices were observed at age 34 between experimental and control groups indicating that childhood physical education offered no advantage in prevention of adult obesity. However, women showed larger coefficients between 12 and 34 years old for both groups indicating that childhood obesity prevention efforts might be more effective in girls.

The nineteenth intervention is from Norway and consisted of providing a free fruit (71). The intervention lasted one academic year and resulted in significant increase in fruit and vegetable intake ($P < 0.001$). The twentieth intervention from the United Kingdom consisted of providing cooled water supply (72). Water consumption significantly increased but no changes in soft drink consumption were noted.

The last intervention was from Singapore. In Singapore, the health ministry launched a nationwide programme called *Trim and Fit* under which nutrition education was integrated into formal school curriculum and control measures were instituted over foods and drinks sold in school canteens (73). Children were encouraged to drink plain water. Outcomes were set for schools and they were awarded 'trim and fat' awards annually. Referrals to student health centre were made for obese children who were more intensively followed. Between 1992 and 2000, obesity rates decreased from 16.6% to 14.6% among primary students (11–12-year-olds) and from 15.5% to 13.1% in secondary students (15–16-year-olds).

Discussion

The purpose of this article was to review international school-based interventions (excluding the United States) in general population for preventing childhood and adolescent obesity that have been published between 1999 and 2005. Based on a review of these interventions, it is evident that there is a need for more primary prevention programmes as there were only a total of 21 interventions from around the world that were found and the problem of obesity in childhood is quite enormous. Many countries that are experiencing the growing problem of overweight and obesity in children and youth have not yet developed and tested school-based obesity prevention interventions. Of the 12 interventions, 16 were performed in Europe (nine in the United Kingdom, three in Germany, one in Austria, one in France, one in Greece and one in Norway), one in North America excluding United States (Canada), one in Asia (Singapore), one in South America (Chile) and two in Australia (one in Australia and one in New Zealand).

The grade range of these interventions was from pre-school (nursery) to high school. However, the majority ($n = 17$) of the interventions have been developed and tested in primary school. Only one intervention has been implemented in pre-school and one intervention permeated K-12 grades. This pattern of majority interventions being for primary school students is similar to the interventions implemented in the United States (74).

The targeting or primary schools makes sense because the dietary and physical activity behaviours are beginning to get formed in these years and interventions designed to build healthy behaviours at this juncture have a potential of long-term impact.

Most of these interventions targeted nutrition behaviours ($n = 9$) followed by seven aiming to modify both physical activity and nutrition behaviours. There were some interventions that focused on only one dimension such as restricting drinking of carbonated drinks or providing physical education time in the school or marking playgrounds. In addition, attempts were made to reduce the behaviour of watching TV. This pattern of large number of interventions targeting both physical activity and nutrition behaviours is similar to the interventions implemented in

the United States (74). While multifaceted, comprehensive programmes are beneficial and single-component programmes also show promise such as the British study reducing carbonated drinks (55) or the Singaporean intervention targeting dietary behaviours (73). However, it cannot be concluded that single-component interventions are superior to multi-component interventions. Hence, it is essential to invest in both multi-component and single-component programmes.

Very few ($n = 5$) interventions from international settings were based on some behavioural theory, a trend that is dissimilar to the interventions developed in the United States, where majority of the published interventions are based on some explicit behavioural theory (74). The three interventions that did utilize a behavioural theory used the social cognitive theory (39). Social cognitive theory has been developed in the United States and tested with a number of behaviours and a number of target populations (75). It is particularly helpful in school-based settings and must be reified and improved further. However, none of the interventions measured and documented changes in behavioural constructs of the theory they have reified. One intervention claimed to have reified three theories. From the perspective of testing efficacy of an intervention, it is beneficial to reify only one theory, so that it can be found out which components or constructs of the theory are working and to what extent. Intervention planners must make efforts to develop psychometrically robust instruments that measure the changes in constructs of the theory that is being used in the intervention. Further, there is need to develop culturally appropriate theories for diverse populations around the globe rather than merely depending upon the theories developed in the United States.

In terms of the duration of the intervention, majority of the interventions ($n = 9$) were one academic year long. One was brief with 8 h of health education, seven were middle-range in length: 8 weeks to three terms (19 sessions) and four were across several grades. In terms of the outcome measures, of the 21 published studies only 11 measured adiposity indices such as BMI, skin fold thickness, etc. Out of these six were able to demonstrate significant changes while five were not able to demonstrate any change. This finding underscores the need to design behaviourally robust and culturally appropriate interventions for the various target populations being served and also measure adiposity indices after sufficient time interval. No pattern could be identified regarding the success of the intervention with the length of the intervention. For example, from the two long-range interventions, one was successful while the other one was not successful. Likewise, for the nine interventions that were one academic year long only six measured obesity indices, four demonstrated positive changes while two did not. Surprisingly, the link of behavioural theory with the success of the intervention was also not evident. Of the two interventions that used a behavioural theory and measured obesity outcome indicators, only one demonstrated significant change in favourable direction with obesity indices.

Four interventions describe the involvement of parents in helping with behaviour change. Of these three have measured outcome indices related to obesity and all three have been successful in demonstrating favourable changes in obesity indices. This is in important finding that underscores the role of parental involvement in school interventions especially in international settings. In many cultures, parents play a much closer, important and influential role in the lives of their children including the influence on dietary and physical activity behaviours. Involving parents early on in developing healthy behaviours for obesity prevention can go a long way (76).

Majority of the interventions have solely focused on individual level behaviour change approaches but a few have attempted to add some policy and environmental level changes. The changes that have been attempted include providing specially cooked vegetarian meals (*StEP TWO programme* in Germany) (46), modification of school meal menus (*APPLES* in the United Kingdom) (53,54) and restriction of selling fatty foods and high-sugar drinks at schools (*Trim and Fat* in Singapore) (73). More interventions that balance educational approaches with health promotion approaches and modify environment and policies would be beneficial in enhancing the efficacy of obesity prevention interventions in school settings. Examples of such efforts can include fluorescent markings of school playgrounds, availability of fruits and vegetables in the school, policies to include parents, operation of fruit tuck shops or kiosks in schools with predetermined conditions, mandating compulsory physical education in each grade throughout the school year and so on.

In terms of the methodology, four studies presented pre-experimental or pilot data or process evaluation data, one study (73) did not elaborate the design but it is evident it had no control group, and 16 studies used experimental designs. It is praiseworthy to have so many studies with experimental designs but often that is the criteria for publication and it rules out inclusion of many studies that may have been developed but were not published because of lack of experimental designs. Most of the interventions have focused on measuring long-term changes (at least 1 year after the baseline) which is commendable. A Canadian study (66–70) has followed up the kids from primary years all the way to adulthood. Finally, four studies are ongoing and more outcome data are expected from these studies.

In terms of measurement of behaviours, 14 studies measured the changes (such as leisure time physical activity, fruits/vegetables consumed, switching off of TV, etc.). All these studies were able to demonstrate positive change towards development of healthy behaviours. Very few stud-

ies ($n = 5$) measured changes in antecedents of behaviour (38,43,63,64,77). The most common indicator measured as an antecedent of behaviour was knowledge. One study measured in-class and at-home task completions (77). There is need to develop scales and measure attitudinal antecedents of behaviour, especially based on behavioural theories.

In terms of the person implementing the intervention, 16 out of 21 interventions utilized existing teachers, some with additional training. This seems to be the most feasible and practical approach. Some interventions used additional professionals with teachers. For example, *PEP* (40–42) in Germany used physicians, physician assistants and dietitians; *KOPS* (43) in Germany used physicians; *StEP TWO* (46) in Germany used a team of nutritionists, gymnasts, psychologists and doctors; and *APPLES* (53,54) in the United Kingdom used school staff; and *PRESTO* (63) in Austria used physicians, psychologists, nutritionists and physical activity experts. James's study (55) was implemented by the investigator herself. Having a multidisciplinary team is often advantageous. Health education interventions for obesity prevention in school settings can benefit from dietetics experts, physical education experts, behavioural theory experts and experts in pedagogy of children. However, it may not always be practically feasible to include outside-school functionaries because of various fiscal, legal and other constraints.

Two interventions identified overweight and obese children and referred them for more intensive follow-up: *StEP TWO* in Germany (46) and *Trim and Fat* in Singapore (73). There seems to be some advantage for this approach as both of these interventions have been successful in reducing BMI. However, this approach has the potential to produce stigmatization and has the possibility to cause psychosocial problems for children (78,79). Hence, caution must be used in employing this approach.

Limitations

There are some limitations in this review. First, interventions published in English language were included and many interventions in international settings are published in other languages such as French (80). Second, only interventions published in three databases were included. While these databases are quite extensive yet these do not tap into all the health literature from all the countries. Further, many of the interventions performed in international settings often do not meet the rigours of being published in peer-reviewed journals and were thus excluded. Finally, differing evaluation methodologies and outcome indices were used in different studies. In the selection criteria attempts were not made to filter studies based on methodology or outcome indicators, but effort was made to be more inclusive of various interventions. As a result, conclusive meta-analysis type of work cannot be performed with these studies and comments cannot be made regarding the effect size of the interventions.

Recommendations from international settings for enhancing school-based interventions

Primary school settings are the most ideal settings for school-based interventions as the obesity prevention behaviours are getting formed at these ages. School-based interventions directed towards addressing childhood obesity prevention should target improvement of physical activity, healthy nutrition and reduction of TV-watching behaviours. In influencing physical activity behaviours increasing the duration especially leisure time, improving motor skills and ensuring daily physical education are important aspects. With regard to nutrition behaviours increasing fruit and vegetable consumption and reducing consumption of sweetened drinks is of importance. Antecedents of these behaviours must be measured. Parental involvement has been found to be an important determinant for success of school-based interventions in international settings. It is important to incorporate this element in all school-based interventions for obesity prevention.

There is need for all interventions to be based on robust and culturally appropriate behavioural theories. Social cognitive theory (39) is one such useful theory. The interventions must clearly measure before and after the intervention the constructs that have been reified. This will give greater confidence in ascertaining that the intervention has been implemented adequately and the link of the results to the theoretical approach can also be attributed. As a consequence, there is need to develop psychometrically robust instruments that are able to discern the changes in the constructs of various behavioural theories being used by intervention researchers. Teachers are effective instruments for delivery of interventions. Where ever possible multidisciplinary team comprising of health professionals can be utilized.

Finally, with regard to intervention activities there is need to supplement individual behaviour change strategies with policy and environmental changes. Some examples of activities performed in international settings are providing specially cooked vegetarian meals, modification of school meal menus, marking school playground and restriction of selling fatty foods and high-sugar drinks at schools. These measures can be replicated in all school-based interventions for obesity prevention.

Conflict of Interest Statement

No conflict of interest was declared.

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