Research in Health Science
ISSN 2470-6205 (Print) ISSN 2470-6213 (Online)
Vol. 5, No. 2, 2020
www.scholink.org/ojs/index.php/rhs

Original Paper

Strategies to Prevent Type 2 Diabetes Mellitus among School Children: A Systematic Review

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Received: April 16, 2020 Accepted: April 25, 2020 Online Published: May 20, 2020
doi:10.22158/rhs.v5n2p64 URL: http://dx.doi.org/10.22158/rhs.v5n2p64

Abstract

Introduction: *The prevalence and socioeconomic burden of type 2 diabetes mellitus (T2DM) and associated co-morbidities are rising worldwide among school children thereby raising a public health concern.*

Aim: *The aim of the review was to explore global literature concerning the various strategies utilised in prevention of type 2 diabetes mellitus among school children and their efficacy.*

Methodology: *A retrospective search of articles published from 2009 to 2019 was done. The following electronic databases; Cochrane, Embase, ERIC, Google Scholar, MEDLINE, PEDRO, PubMed and Science Direct were individually searched using specifically developed search strategies. Methodological quality was evaluated using the Critical Appraisal Skills Programme (CASP) tool and by two independent reviewers.*

Results: *Eleven studies of sound quality were included. The studies show that primary prevention of type 2 diabetes among school children is cardinal as children will grow up knowing about the disease and its consequences. The prevention of type 2 diabetes mellitus requires various combinations of interventional program elements including dietary education/counselling, physical activity, diabetes knowledge, competence building, school, social and community support being considered concurrently. None of the studies identified was done in Africa.*

Conclusion: *Findings concretise that healthy diets and exercise outcomes coupled with explicit programs are key to type 2 diabetes mellitus prevention among school children.*

Keywords
Diabetes mellitus type 2, school children, prevention strategies, exercise, nutrition

1. Introduction

Type 2 diabetes mellitus (T2DM) is one of the fastest growing and largest global health burdens with high levels of morbidity and mortality (Wichit et al., 2016). Due to its chronic nature, which demands lifelong maintenance, T2DM is also a tremendous economic burden on the individual, family and the entire health care system (Meetoo, 2014; Wang et al., 2009). The combined global prevalence of diabetes and prediabetes among youths has increased from 9% to 23% (May et al., 2012) with a rising in overall prevalence diagnosed cases in the past decade (Yeow et al., 2019). Prediabetes prevalence is related to weight and is present amongst 12% with normal weight, 18% who are overweight and 30% in obese adolescents (Vangeepuram et al., 2015). If prediabetes incidence remains constant, the proportion of youth with type 2 diabetes is projected to increase by 49% by 2050 globally with the mean age at diagnosis of type 2 diabetes being 12-14 years and initial diagnosis being as young as 5 years (Imperatore et al., 2012). According to Smart et al. (2018), the changing disease rates are almost certainly attributed to changes in several dietary factors such as changes in the quality, quantity and source of food, over-consumption of cheap fatty and energy dense foods as well as changes in lifestyle. A reduction in physical activity and an increase in sedentary lifestyles including spending long hours playing games on the computer, iPads and tablets, play station and watching TV has also contributed significantly to the increase in prevalence rates (Temneanu et al., 2016; Gulati et al., 2014; WHO, 2014).

Diabetes has classically been defined as a group of metabolic diseases characterized by hyperglycemia which is increased concentration of blood glucose due to disturbances in glucose metabolism as a result of: (i) peripheral insulin resistance in muscle and adipose tissue; (ii) excessive hepatic glucose production (iii) impaired insulin secretion from the pancreas, (iv) or a combination of all three (ADA, 2019; Yeow et al., 2019; Meetoo, 2014; Polikandrioti & Dokoutsidou, 2009). Symptoms of marked hyperglycemia include polyuria, polydipsia, weight loss, sometimes with polyphagia, and blurred vision, impairment of growth and susceptibility to certain infections may also accompany chronic hyperglycemia especially in children (ADA, 2019). The American Diabetes Association (ADA, 2019; 2018), indicated that type 2 diabetes is diagnosed based on a fasting plasma glucose (FPG ≥126 mg/DL [7 mmol/L]) or the two hour plasma glucose value following a 75 g oral glucose tolerance test (>200 mg/DL [11.0 mmol/L]) or having an HbA1c of 6.5%. Glycosylated haemoglobin (HbA1c) to which glucose is bound, is tested to determine average blood glucose levels over the past two to three months (ADA, 2018; 2010; IDF, 2017; 2015), as this is widely regarded as an accurate measurement for diabetes assessment. Type 2 diabetes mellitus, once considered a rare condition among the young population, now accounts for about 15% to 45% of all newly diagnosed cases of diabetes in children and teenagers drastically surpassing type 1 diabetes in some regions (Cara, 2019).

Children in whom T2DM develops are at risk of complications from the disease, including retinopathy, neuropathy, cardiovascular, renal disease and early mortality (Foster et al., 2010). The longer individuals have these conditions, the greater the risk of complications, resulting in discomfort, ill health and absenteeism from school, they also suffer psychosocial consequences including; social alienation, low self-esteem, discrimination and decreased mental acuity such as lower grade point averages, standardized test scores and perceived academic performance (Totura et al., 2015; Contento et al., 2010). Type 2 diabetes mellitus also imposes a substantial burden on the economy worldwide in the form of increased medical costs (ADA, 2013). The US national health expenditure to treat T2DM and its complications is estimated to be around US$210 billion among adults and US$14 billion among children per year and this has drastically increased in recent years (Totura et al., 2015). The direct costs of T2DM consume from 2.5% to 15.0% of annual healthcare budgets depending on available treatments and local prevalence worldwide. Hence interventions aimed at preventing childhood T2DM and the associated risks are increasingly important at primary level (Totura et al., 2015; Wang et al., 2009).

Schools offer an ideal setting for lifestyle interventions because the obesogenic lifestyle behaviours are less well developed in children and are therefore amenable to change (Pansier & Schulz, 2015). Schools present opportunities for reducing the risk of diabetes since no other institution has as much contact time with children, moreover, schools can implement environmental changes that affect available foods, physical activity/education, class curricula, policies and the acceptability of healthy behaviours (Chinnici et al., 2019; Manios et al., 2018; Hall et al., 2014; Muzaffar et al., 2014; DeBar et al., 2011; Singhal et al., 2011; Foster et al., 2010). Furthermore, schools are uniquely positioned to promote healthful interventions that can provide an unparalleled opportunity to reach many children including the ones with the highest risk of developing type 2 diabetes (Chinnici et al., 2019; Manios et al., 2018; Hall et al., 2014; Muzaffar et al., 2014; DeBar et al., 2011). It is also conjectured that children will adhere to health attitudes and habits into adulthood (Totura et al., 2015). Due to the recent emergence of type 2 diabetes among children, prevention or delayed onset of the disease is vital. Various programs have therefore been designed and launched to address T2DM among school-attending children (DeBar et al., 2011).

According to the literature, the evaluation of health interventions is essential for two main reasons: i) improving programmes; and ii) improving policy (Glasgow & Linnan, 2008; as cited in Pansier & Schulz, 2015). Evaluation may help improve programmes and their outcomes by adjusting programme content, identifying the best strategies for increasing participation and adherence, addressing problems and identifying the most effective methods. Evaluation may also help advocate for the programme and mobilize health authorities' support to implement policies and trigger action (Pansier & Schulz, 2015). When designing effective preventive interventions among school children, it is important to identify modifiable risk factors such as diet, physical activity and physical inactivity as well as theories of behaviour change, the setting and ecology, and policies and organisational factors surrounding the school children. Pansier and Schulz (2015) in their systematic review highlight that most school T2DM intervention programs had inadequate methodologies and had mixed results. The review concluded that further research was needed to define effective diabetes interventions for schools. This was in line with this review as most of the studies have failed to give a clear description of the programs behind the intervention design. The current review observed that locally available resources such as indigenous foods are underutilised especially in Africa as a preventive strategy for T2DM, as no study showed their utilisation despite the fact that food types differ from region to region. Thus, a diet adopted from one region for example may not be effective in another. The current review also identified a dearth in programs and literature on the prevention of T2DM, especially in Africa. These were identified as a gaps that needed to be explored further. Therefore, the aim of this review was to explore global literature concerning the various strategies utilised in the prevention of type 2 diabetes mellitus among school children and their effectiveness.

2. Method

A comprehensive search of global literature was performed in international scientific databases. The search considered any full-text peer-reviewed research studies around the world relevant to the topic. The PICO (Population, Intervention, Comparison and Outcomes) was used as the searchable format for the clinical question and to review the titles and the abstracts relevant to the study. Reference lists of included studies and key reviews in the area were also manually searched for additional articles. In order to exhaust the search databases among those selected, those which made provision for related articles were also explored. To determine the eligibility of the article for inclusion in the study, all identified literature was screened using the Sackett’s level of evidence hierarchy system (Sackett, 1989) and only randomised controlled trials were considered.

2.1 Inclusion Criteria

Only literature published in the English language from 2009 to 2019 was considered. Descriptive studies focusing on the needs of school children with diabetes or identifying the gaps in diabetes care in school were excluded. The study considered only randomised controlled trial (RCTs) with a comparison arm or control group and with or without additional behaviours other than diet and physical activity and had clearly outlined outcome measures. Only studies with preventive/intervention programs and focused on school children aged between 9 to 18 years (grades 5 to 8 in upper primary or middle school) were considered. Studies focusing on other forms of diabetes other than type 2 were excluded. Studies focusing on children with diabetes or prevention programs outside the school, such as summer camps or paediatric centres, were also excluded. However, some of the relevant information of some excluded studies was used in the background of this study. The final review of all the identified literature was conducted by professional independent reviewers to minimize bias.

The databases searched included: Cochrane, Embase, ERIC, Google Scholar, MEDLINE, PEDRO, PubMed and Science Direct. The MeSH terms used for searching for the literature were: Programs OR

Models and Type 2 Diabetes Mellitus OR glucose OR HbA1c and Prevention and Schools OR Schoolchildren OR Paediatrics OR Preadolescents. Boolean operators “and” and “or” were used in some databases. Other databases did not produce any results except the ones given in Table 1.

2.2 Search Results

The search generated a total of 26 618 articles of which 17 were removed due to duplication. Of the 26 601 that remained, 22 were found relevant to this topic and were retained for methodological assessment. A total of 26 590 articles were excluded because they did not conform to the objectives and inclusion criteria of this review. Details of the search results are illustrated in Figure 1.

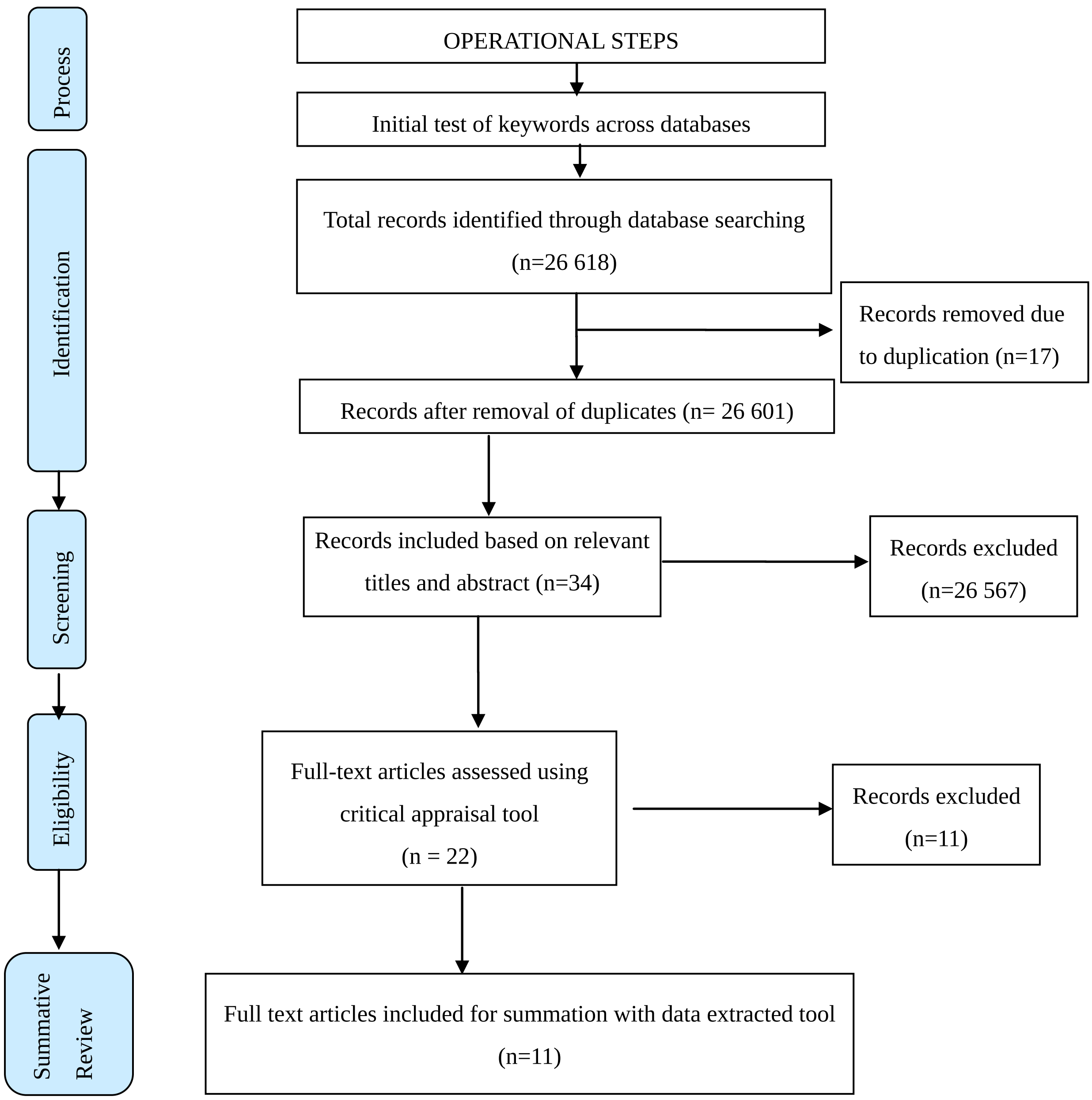

Figure 1. Process of Systematic Review (Adapted from Moher et al., 2009)

2.3 Assessment of Methodological Quality

After selection of the 22 studies presumed to be of acceptable designs, the Critical Appraisal Skills Programme (CASP) tool (CASP, 2018) was used to assess their methodological quality. The CASP for randomised controlled trial was used as only randomised controlled trials were retained. The CASP for randomised controlled trial assesses articles based on 11 questions, hence having scores ranging from 1-11 (Guyatt, Sackett, & Cook, 1994). The scores are classified as good if an article scores between (8-11/11), moderate (5-7/11) and poor (1-4/11). Of the 22 retained articles, 11 had good methodological quality and were finally included in the review (Table 1). The other 11 that were initially found relevant to the review were later excluded as they did not meet the methodological quality.

Table 1. Methodological Quality Scores of Included Studies

Author & Year	**Title**	**Database**	**Level of evidence** (Design)	**Methodological quality** (CASP score)
Cline et al. (2014).	A School-Based Type 2 Diabetes Prevention Program for Canadian Elementary Students.	Google Scholar	Randomised Controlled Trial	8/11
Eskicioglu et al. (2014).	Peer mentoring for type 2 diabetes prevention in first nationals children.	Google Scholar	Randomised Controlled Trial	8/11
Muzaffar et al. (2014).	The Impact of Web-Based HOT (Healthy Outcomes for Teens) Project on Risk for Type 2 Diabetes: A Randomized Controlled Trial.	PEDRO	Randomised Controlled Trial	8/11
Rush et al. (2014).	Project Energize: whole-region primary school nutrition and physical activity programme; evaluation of body size and fitness 5 years after the randomised controlled trial.	Cochrane	Randomised Controlled Trial	8/11
DeBar et al. (2011).	Student public commitment in a school-based diabetes prevention project: impact on physical health and health behaviour.	Cochrane	Randomised Controlled Trial	9/11
Singhal et al. (2011).	Impact of Intensive School-Based Nutrition Education and Lifestyle Interventions on Insulin Resistance, b-Cell Function, Disposition Index, and Subclinical Inflammation among Asian Indian Adolescents: A Controlled Intervention Study.	Embase	Randomised Controlled Trial	9/11
Contento et al. (2010).	Adolescents Demonstrate Improvement in Obesity Risk Behaviors after Completion of Choice, Control & Change, a Curriculum Addressing Personal Agency and Autonomous Motivation.	PEDRO	Randomised Controlled Trial	9/11
Foster et al. (2010).	A School-Based Intervention for Diabetes Risk Reduction.	Embase	Randomised Controlled Trial	8/11

Slawta, J. N. & DeNeui, D. (2010).	Be a Fit Kid: Nutrition and Physical Activity for the Fourth Grade.	Google Scholar	Randomised Controlled Trial	8/11
Grey et al. (2009).	A Multifaceted School-based Intervention to Reduce Risk for Type 2 Diabetes in At-Risk Youth	Science Direct	Randomised Controlled Trial	8/11
Venditti et al. (2009).	HEALTHY study rationale, design and methods: moderating risk of type 2 diabetes in multi-ethnic middle school students.	PubMed	Randomised Controlled Trial	9/11

3. Results

The 11 studies included in the review were all randomised controlled trials. Most of the studies included (90%) were carried out in North America (7 from USA and 2 from Canada) with 10% (1) from New Zealand and non from Europe, Asia and Africa. Most European and Asian studies failed to meet the inclusion criteria as they mainly focused on either treatment and not prevention or an older age group (adolescents). Studies found about Africa were mostly about prevalence or prevention of T2DM in the age group above 18 years. All the studies included in this review were carried out among school going children. The sample of the participants in the included studies ranged from 65 to 4603 with the age group ranging from 9 years to 18 years and the sample mean age of 13.5 years.

3.1 Outcomes

Six of the studies reported significant improvement in physical activity performance and knowledge in the intervention group compared to the control group with results significant at $P<0.05$ or less ($P<0.01$), CI 95% (Cline et al., 2014; Muzaffar et al., 2014; Rush et al., 2014, Contento et al., 2010; Slawta & DeNeui, 2010; Grey et al., 2009). Four of the studies reported significant improvements in choice and knowledge of healthy nutrition/diet in the intervention group than the control group with results significant at $P<0.05$ or less ($P<0.01$) and CI 95% (Cline et al., 2014; Eskicioglu et al., 2014; Contento et al., 2010; Slawta & DeNeui, 2010). Six studies reported significant changes in BMI between the groups with results significant at $P<0.05$ or less ($P<0.01$) and CI 95% (Eskicioglu et al., 2014; Rush et al., 2014; DeBar et al., 2011; Singhal et al., 2011; Foster et al. 2010; Grey et al. 2009). Three studies reported significant changes in waist circumference (WC) at $P<0.05$ or less ($P<0.01$) and at a CI of 95% when comparing intervention from control groups (Eskicioglu et al., 2014; Singhal et al., 2011; Foster et al., 2010). A study by Grey et al. (2009) reported significant changes in triglyceride levels with reductions significant in the intervention group at $p = 0.012$ compared to the control. One study reported a significant reduction of body fat between the intervention and the control group at $t (46) = -2.07$; $P< 0.05$; $r2 = .08$ (Slawta & DeNeui, 2010). A study by Singhal et al. (2011) showed that b-Cell function (HOMA-bCF) and Disposition Index (DI) were significantly higher ($P= 0.037$); (30.3 73.4; $P < 0.037$) in intervention group respectively, whereas high sensitivity C-reactive protein (hs-CRP) was significantly lowered ($P < 0.001$), compared to control group with decrease in homeostasis model assessment of insulin resistance (HOMA-IR).

These studies measured outcomes associated with the prevention of T2DM and showed significant improvements post intervention. A summary of the findings of the studies included in this review is illustrated in Table 2.

Table 2. Summary of Studies Included in the Review

Reference	**Country**	**Population/Sample size**	**Objective**	**Model/theory /Framework of prevention**	**Statistical significance (outcome)**	**Findings(+)/ gaps(-)**
A School-Based Type 2 Diabetes Prevention Program for Canadian Elementary Students. Cline et al. (2014).	Canada	296 (207 intervention: 89 control).	To raise awareness about the role of physical activity and healthy eating in type 2 diabetes prevention using the everyone jump program.	Education manual through curriculum.	2 x 2 MANOVAs; significant interaction for: Steps Taken & physical activity time ($p < .01$, eta^2=.03); Self-reported physical activity ($p < .05$, $eta^2 = .04$); & Canada's food guide knowledge ($p < .05$, $eta^2 = .02$).	+Program fostered diabetes-related health literacy. -However, only physical activity program objectives were met. -Variation in implementation by teachers -Lacks ecological & partnership involvement
Peer mentoring for type 2 diabetes prevention in first nationals children. Eskicioglu et al. (2014).	Canada	151 (51 intervention: 100 control).	To assess the efficacy of an afterschool, peer-led, healthy living program on adiposity, self-efficacy and knowledge of healthy living behaviours in children.	Class curriculum & Four R's model.	Results lower in intervention WC (–2.5 cm [95% CI: –4.1 to –0.90]; P = .002) & BMI z score (–0.09 [95% CI: –0.16 to –0.03]; P = .007) improvements in knowledge of healthy dietary choices (2.25% [95% CI: –0.01 to 6.25]; P = .02). Self-efficacy was associated with the change in WC after the intervention (b = –7.9, P = .03).	+An after-school, peer-led, healthy living program attenuated weight gain & improved healthy living knowledge in children. -Lacked ecological, parental & partnership involvement.
The Impact of Web-Based HOT (Healthy Outcomes for Teens) Project on Risk for Type 2 Diabetes: A Randomized Controlled Trial. Muzaffar et al. (2014).	USA	214 (124 intervention: 90 control).	To improve knowledge, outcome expectations, self-efficacy and self-reported food intake and skills.	Online curriculum learning & constructs from social cognitive theory & social persuasion	Subjects in the AOL (intervention) improved significantly for all 5 categories (P = 0.001) and also for outcome expectations for exercise (P = 0.001) than those in POL (control) (by Mann–Whitney test).	+Teens in AOL of HOT Project acquired skills for planning a meal and improved outcome expectations for exercise. -Family & peer support not incorporated. -Pre & Post-intervention too short -No post-intervention follow up e.g. BMI check
Project Energize: whole-region primary school nutrition and physical activity programme; evaluation of body size and fitness 5 years after the randomised controlled trial. Rush et al. (2014).	New Zealand	2 Groups (2474 younger [age6-8]: 2330 older age [10-12]).	1. To slow rate of excess weight gain, reduce the risk of obesity & type 2 diabetes in children through a population-based public health service. 2. To determine effect of physical activity & nutrition program on indices of obesity, BMI & physical fitness	Public health actions.	Energised young & older children had BMI lower by 3·0% (95% CI 25·8, 21·3) & 2·4% (95% CI 24·3, 20·5). Physical fitness (time taken to complete a 550m run) was significantly higher in the Energized children (13·7 and 11·3 %, respectively)	+Energize programme in schools leads to reductions in prevalence of overweight, obesity & gains in physical fitness, thus to reducing risk of obesity & type 2 diabetes. -Lack of contemporaneous comparison group -Inability to quantify the intervention done by school -Different age groups -Lacked ecological, parental & partnership involvement
Student public commitment in a school-based diabetes prevention project: impact on physical health and health behaviour. DeBar et al. (2011).	USA	4603 (42 schools, 21 intervention: 21 control).	Student's "public commitment"–voluntary participation in a school-based intervention to prevent diabetes, reduce obesity and improve health outcomes.	Public commitment theory.	Intervention group had low BMI at 95th percentile compared to control (21.5% vs. 26.6%, p = 0.02). BMI even greater among subgroup obese or of overweight at baseline; 44.6% for intervention vs 53.2% for control (p = 0.01).	+Participating in public commitment during HEALTHY intervention potentiated changes in behavioural, nutrition & physical activity among students & their peers. -Non randomisation as participation was voluntary -Little to no teacher & administrative involvement -Lacked ecological, parental & partnership involvement

Impact of Intensive School-Based Nutrition Education and Lifestyle Interventions on Insulin Resistance, b-Cell Function, Disposition Index, and Subclinical Inflammation among Asian Indian Adolescents: A Controlled Intervention Study. Singhal et al. (2011).	India	106 (56 intervention:50 control)	To assess the impact of intensive and repetitive nutrition education and lifestyle interventions on insulin resistance, b-cell function, disposition index (DI), and subclinical inflammation in Asian Indian adolescents (15–17 years) residing in North India.	MARG: "**M**edical education for children/ **A**dolescents for **R**ealistic prevention of obesity and diabetes and for healthy a**G**eing"	b-Cell function (HOMA-bCF) & DI were significantly higher (P= 0.037); (30.3 73.4; P < 0.037) in intervention group respectively, whereas high sensitivity C-reactive protein (hs-CRP) was significantly lowered (P < 0.001), compared to control group. Pearson's coefficient of correlation in intervention group showed decrease in mean WC significantly (r=0.267, P < 0.05) with decrease in homeostasis model assessment of insulin resistance (HOMA-IR).	+Multi-component intervention model led to positive behavioral, anthropometric & metabolic changes in adolescents during a relatively short span of 6 months. +Focused on at risk and not at risk groups. -Less emphasis on utilisation of PA as only PA counselling was utilised. -Substantial drop-out rate for biochemical data at follow-up in both groups.
Adolescents Demonstrate Improvement in Obesity Risk Behaviours after Completion of Choice, Control & Change, a Curriculum Addressing Personal Agency and Autonomous Motivation. Contento et al. (2010).	USA	10 middle schools (562 intervention: 574 control.	To examine the impact of curriculum intervention, on adoption of energy balance- behaviours of decreasing sweetened drinks, packaged snacks, fast food &leisure screen time & increasing water, fruits & vegetables, & physical activity, on psychosocial mediators of behaviours.	Choice, Control & Change, Curriculum theories based on the Social Cognitive & Self Determination theory.	Positive outcome expectations increased substantially for all seven variables with results based on analysis of covariance with group (control/intervention) as a fixed factor and pretest scores as covariate. Results were significant at P=0.05.	+The Choice, Control & Change curriculum was effective in improving behaviours related to reducing obesity risk and type 2 diabetes -Behavioural data was self-reported -Lacked ecological, parental & partnership involvement.
A School-Based Intervention for Diabetes Risk Reduction Foster et al. (2010).	USA	4603 (42 schools, 21 intervention: 21 control)	Examined the effects of a multicomponent, school-based program addressing risk factors for diabetes among children whose race, ethnicity & socioeconomic status placed them at high risk.	School curriculum FLASH theory (Fun Learning Activities for Student Health).	Intervention schools had greater reductions in secondary outcomes of BMI z score, percentage of students with waist circumference at/ above 90th percentile, fasting insulin levels were (P = 0.04 for all comparisons) & prevalence of obesity (P = 0.05).	+Intervention resulted in significantly greater reductions in various indexes of adiposity. -Sample not nationally representative -Intervention was facilitated by staff & funds provided hence efficacy of study cannot assess feasibility, effectiveness, or sustainability of an intervention program outside a study setting. -Lacked ecological, parental & partnership involvement.
Be a Fit Kid: Nutrition and Physical Activity for the Fourth Grade. Slawta, J. N. & DeNeui, D. (2010).	USA	65 (45 intervention: 20 control).	To determine the efficacy of the Be a Fit Kid program by examining health-related improvements.	PRECEDE-PROCEDE model & Classroom curriculum.	Comparing intervention to control group revealed significant differences in the mile run time $t(52) = -5.67$; $p < .01$; $r2 = .38$, sit-ups $t(52) = 6.42$; $p < .01$; $r2 = .44$, body fat $t(46) = -2.07$; $p < .05$; $r2 = .08$, and nutrition knowledge $t(59) = 2.57$; $p < .05$; $r2 = .10$. With the exception of nutrition knowledge $t(17) = -3.04$; $p < .01$; $r2 = .35$, there were no significant changes in any of the variables in the control group relative to baseline value	+Comprehensive physical activity & nutrition programs included in the school curriculum may be effective for improving cardiovascular health & reducing future risk for lifestyle-related diseases. -Small sample -Focused more on physical fitness & less on diet & dietary policies. -Less ecological emphasis.
A Multifaceted School-based Intervention to Reduce Risk for Type 2 Diabetes in At-Risk Youth. Grey et al. (2009).	USA	198 (4 schools intervention: 2 schools control.	To evaluate the impact of a multifaceted, school-based intervention on inner-city youths at risk for T2DM & to determine whether the addition of coping skills training (CST) & health coaching improves outcomes.	Social learning theory.	Control group had higher depressive symptoms ($p = 0.027$); lower self-efficacy for physical activity ($p = 0.012$); and higher triglyceride levels ($p = 0.012$), ($p = 0.012$). At 12 months BMI was high in control ($p < 0.001$).	+A multifaceted, school-based intervention reduced metabolic risk in urban, minority youth. -Small sample size resulting in an inability to address mediator effects -Tools to measure food choices & self-efficacy for PA had low internal consistency -Poor attendance, only 34% completed program -Lacked ecological, parental & partnership involvement.

HEALTHY study rationale, design and methods: moderating risk of type 2 diabetes in multi-ethnic middle school students. Venditti et al. (2009).	USA	4603 (42 schools, 21 intervention: 21 control).	To moderate risk factors of T2DM in middle school students.	School Curriculum.	Sample size calculations assumed a two-sided significant level α=0.05 and 90% power. This comparison was only at baseline where there was no significant difference in variables between intervention & control groups. (BMI, WC, glucose, Fasting insulin, BP, cholesterol lipoprotein & Triglycerides.	+ HEALTHY model can be successful & can be implemented nationwide though may need more fundamental changes to be more effective. - Lacks collaboration with partners e.g. media houses, food manufacturers. -Little ecological facilitator considerations. E.g. facilitators & barriers.

4. Discussion

4.1 Prevention Strategies/Components

In all the eleven studies included, behavioural knowledge and skills modification involving physical activity education and healthy nutrition were utilised as part of the prevention strategy (Cline et al., 2014; Eskicioglu et al., 2014; Muzaffar et al., 2014; Rush et al., 2014; DeBar et al., 2011; Singhal et al., 2011; Contento et al., 2010; Foster et al., 2010; Slawta & DeNeui, 2010; Grey et al., 2009; Venditti et al., 2009) with one study mainly utilising an online education intervention of balancing food intake and physical activity (Muzaffar et al., 2014). Physical activity mainly involved promoting physical activity participation, increasing the intensity and amount of time students spent in moderate to vigorous physical activity (Cline et al., 2014; Eskicioglu et al., 2014; Muzaffar, et al. 2014; DeBar, et al 2011; Rush et al. 2014; Singhal et al., 2011; Contento et al., 2010; Foster et al., 2010; Slawta & DeNeui, 2010; Grey et al., 2009; Venditti et al., 2009) by incorporating activities sufficient to raise heart rate to 130 beats or more per minute (Cline et al., 2014; Eskicioglu et al., 2014; Rush et al., 2014; Foster et al., 2010; Slawta & DeNeui, 2010; Venditti et al., 2009). Eight of the eleven studies used the class curriculum in disseminating information promoting healthy lifestyles and improving behaviours related to reducing obesity risk and type 2 diabetes (Cline et al., 2014, Eskicioglu et al., 2014; Muzaffar et al., 2014; Singhal et al., 2011; Contento et al., 2010; Foster et al., 2010; Slawta & DeNeui, 2010; Grey et al., 2009; Venditti et al., 2009).

Nutritional education occurred in all the studies as a combination of dietetic counselling and/or basic nutritional knowledge, consumption of high quality to low quality food, such as water, fruits and vegetables instead of sweetened drinks, packaged snacks and fast foods, and change in canteen menu, foods and beverages in the school environment. Four studies involved communication strategies and social marketing (DeBar et al., 2011; Singhal et al., 2011; Foster et al., 2010; Venditti et al., 2009) by utilising peers, posters, banners and branding (Singhal et al., 2011; Foster et al., 2010; Venditti et al., 2009).

4.2 Efficacy of Programs

A variety of school based prevention strategies/interventions were implemented in various countries with non-found in Africa, therefore making it difficult to generalise the results especially in the African context. In some studies, sampling and sample sizes were limited as some studies either lacked a contemporaneous comparison group (Rush et al., 2014), had a small sample size (Grey et al., 2009) or had inadequate randomisation as it was in some cases on voluntary (DeBar et al., 2011) resulting in these studies failing to adequately address mediator effects. Other studies used tools with low internal consistency to measure food choices & self-efficacy for physical activity therefore making replicability of the study difficult (Grey et al., 2009). Some studies lacked follow-up post intervention (Rush et al., 2014) which provided less evidence of effectiveness of intervention. Intervention in some studies was facilitated by staff and funds provided hence efficacy of such studies cannot assess feasibility, effectiveness or sustainability of an intervention program outside the study setting (Foster et al., 2010). A study by Singhal et al. (2011) which incorporated ecological and parental support among various intervention facets had more positive outcomes and should hence be considered for developing future T2DM based interventions. Therefore, comprehensive evaluation of school-based diabetes projects will contribute to adjusting and improving the effectiveness of prevention/intervention as well as serve as an advocacy tool for improving school policies on T2DM among school children. A summary of the findings of the studies included in this review is illustrated in Table 2.

5. Conclusion

This review responds to the call that type 2 diabetes is on the rise among school children and requires attention as shown by the number of preventative/ interventional studies conducted in various parts of the world. In order for preventative approaches to achieve sustained success, the target populations must be empowered to possess a sense of ownership of the process of adopting healthier lifestyle behaviours. Designing a preventative strategy for type 2 diabetes among children requires particular emphasis on theoretical constructs that engage in interactions of personal, social and environmental factors and interactions should promote the adoption of healthful behaviours in a supportive, meaningful and personally enjoyable context. The review shows that it requires various integrations of interventional elements including dietary education/counselling, physical activity, diabetes knowledge, competence building, social marketing, social as well as community support and environmental factors being considered concurrently. The review has shown further that there’s still a dearth in research and information on the prevention of type 2 diabetes mellitus among school children, especially in Africa. Therefore, more studies of sound methodological quality exploring this area need to be done.

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