Global Journal of Health Science; Vol. 14, No. 4; 2022
ISSN 1916-9736 E-ISSN 1916-9744
Published by Canadian Center of Science and Education

Scoping Review of School-Based Obesity Interventions among Children and Adolescents in Arabic Speaking Countries

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Received: February 8, 2022 Accepted: March 1, 2022 Online Published: March 15, 2022

doi:10.5539/gjhs.v14n4p40 URL: https://doi.org/10.5539/gjhs.v14n4p40

Abstract

Background: Childhood and adolescent obesity globally presents a huge public health problem and the dramatic increase in its prevalence and associated poor health outcomes pose serious concerns among Arabic-speaking countries.

Aim: This scoping review seeks to identify the characteristics and assess the effectiveness of school-based health promotion interventions on prevention or reduction of overweight/obesity among children and adolescents. This review further describes the implementation and evaluation of nutrition and physical activity interventions and their measured health outcomes for schools in Arabic speaking countries.

Methods: We searched 10 electronic databases (PubMed MEDLINE, Scopus, CINAHL, Cochrane Central Register of Controlled Trials (CENTRAL), ERIC, EMBASE, ProQuest, EBSCO Host and Global Health) from 2010 to 2020 for studies evaluating school-based health promotion interventions on obesity or overweight among children and adolescents in Arab speaking countries. Sixteen studies met the inclusion criteria for this review and narrative synthesis was conducted.

Results: The 16 articles reported on eight discretely different interventions which were largely school-based and examined physical activity and/or nutritional changes as well as changes in knowledge and attitude in regard to physical activity and nutrition.

Conclusion: Our review demonstrates an inconclusive and mixed effect of behavioural and physical activity intervention on prevention or reduction of obesity and/or overweight. While the strengths and limitations of the various interventions may have influenced the outcomes, long-term school-based interventions with rigorous methodological and theoretical frameworks are necessary to assess the true impact of these interventions on childhood and adolescent obesity in Arab speaking countries.

Keywords: School-based interventions, childhood obesity, adolescent obesity, Arabic speaking countries

1. Introduction

Obesity among children and adolescents is a challenging public health issue globally (Karnik & Kanekar, 2012). The dramatic increase in the prevalence of obesity and its associated poor health outcomes is concerning in Arabic-speaking countries located in the East Mediterranean, Arabian Peninsula, and northern parts of Africa (Al Hammadi & Reilly, 2019; World Health Organization, 2016). In this region, multifactorial influences, comprising rapid societal and environmental transformations, education, and difference in socioeconomic backgrounds has led to an increase in lifestyle-related diseases and increased rates of childhood obesity (Badran & Laher, 2011). In recent decades, the populations living in middle eastern countries have undergone a nutritional transition where traditional foods have been substituted by fast foods which are usually energy-dense and nutrient poor (Al Moraie, 2014; Alzaman & Ali, 2016; Badran & Laher, 2011). The consumption of unhealthy foods and sugary carbonated drinks, especially among children and adolescents is increasing rapidly (Aboul-Enein, Bernstein, & Neary, 2016; Al Dhaifallah, Mwanri, & Aljoudi, 2015). In addition, people from Middle Eastern Arabic countries are more

likely to adopt sedentary lifestyles when compared to other non-Arab cultures with this including increased television viewing time, playing video games and Internet use during leisure time (Musaiger, 2011). The increased socio-economic status among residents in high income Arab countries in recent decades has resulted in increased use of personal cars for transportation (Badran & Laher, 2011). Children are less likely to walk to school and play outdoors than in the past and report increased use of indoor games and television viewing (Sahoo et al., 2015). Poor dietary habits and a sedentary lifestyle among children can lead to overweight and obesity.

Obesity is associated with high morbidity and mortality rates (Kuźbicka & Rachoń, 2013). Non-communicable diseases such as cardiovascular diseases and various cancers are some of the most common health outcomes attributed to overweight and obesity (Bechard, Rothpletz-Puglia, Touger-Decker, Duggan, & Mehta, 2013; Najeh, Kandi, Rguibi, & Belahsen, 2012). As a result of obesity, children may experience increased psychological impact such as anxiety, depression, negative self-perceptions, low self-esteem, decreased physical functioning due to health-related issues such as joint pain and muscle pain and poor quality of life (Badran & Laher, 2011; Halasi et al., 2018). The parents of children with overweight and obesity may also experience emotional distress (Rankin et al., 2016).

Prevention interventions are considered important in public health efforts to reduce childhood obesity (Pandita et al., 2016). The school community provides an ideal setting for health promotion interventions (Rebecca Langford et al., 2017). School-based health promotion interventions can reach most children and adolescents at a critical age when many eating habits, attitudes, and lifestyles are being established (World Health Organization, 2014). The school setting also provides opportunities for school students to practice healthy eating through appropriate food selection in the school canteen and to participate in physical activity through physical education classes (Chen et al., 2015). The World Health Organization (WHO) Health Promoting Schools (HPS) framework (Rebecca Langford et al., 2015) is the most comprehensive and multifaceted school-based approach (Griebler, Rojatz, Simovska, & Forster, 2017). The HPS framework includes strategies across three domains including: curriculum, learning and teaching; school organisation, ethos and environment; and partnerships and services. Despite complex socio-ecological interactions, a review of HPS interventions found evidence of reduction of body mass index, increased physical activity, increased consumption of fruit and vegetables and reduction of unhealthy behaviours including drug use, cigarette smoking and bullying (R. Langford et al., 2014). Despite the global recognition of the importance of a whole school approach, there are challenges with implementation including: lack of community involvement and intra-sectorial and inter-sectorial collaboration; inadequate infrastructure, capacity and human resources; and inconsistent policy-making, regulations, and management approach (Fathi, Allahverdipour, Shaghaghi, Kousha, & Jannati, 2014).

Reducing childhood obesity requires effective lifestyle and behavioural interventions that target healthy eating and physical activity behaviours among children and adolescents as well creating supportive environments (Xu et al., 2015). Schools were identified as the ideal setting for health promotion because health and education are closely linked and children spend a significant amount of time in school (Rebecca Langford et al., 2015). Though overweight and obesity interventions in schools are challenging, the collaborative assistance of parents and teachers is likely to enhance community knowledge, encouraging health support and thus enhancing general family quality of life (Allafi, 2020; A. Bani Salameh et al., 2017; Ben Cheikh et al., 2020; Dendana et al., 2017; Habib-Mourad et al., 2014). Therefore, exploring the effectiveness of interventions is a key action that can assist with health planning and prevention of childhood overweight and obesity in the future.

This scoping review identifies the characteristics and effectiveness of school-based health promotion interventions focusing on overweight/obesity prevention or reduction among children and adolescents in Arabic speaking countries. This review examined implemented and evaluated nutrition and physical activity interventions and measured health outcomes for schools in Arabic speaking countries.

2. Methodology

2.1 Information Sources

Different databases and other registries (Google, Google Scholar, reference lists of relevant articles) were used with broad and inclusive search terms to identify eligible studies published during the last 10 years. Electronic databases used: PubMed MEDLINE, Scopus, CINAHL, Cochrane Central Register of Controlled Trials (CENTRAL), ERIC, EMBASE, ProQuest, EBSCO Host and Global Health. Reference lists of relevant articles such as systematic reviews on Google and Google Scholar were manually searched. English or Arabic language restrictions were applied.

2.2 Intervention Selection

This scoping review focused on interventions with school-aged children and adolescents in Arabic speaking countries (i.e. Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates, Algeria, Palestinian Territories,

Comoros, Djibouti, Egypt, Iraq, Jordan, Lebanon, Libya, Mauritania, Morocco, Somalia, Sudan, Syria, Tunisia and Yemen). Studies included focus on school-aged children aged from five to 18 years and school-based interventional studies aiming to prevent or reduce overweight and obesity. All studies were published over the last 10 years in peer-reviewed articles, written in English or Arabic with full text available. Quantitative and qualitative studies were included. Systematic reviews and other secondary studies, studies published in languages other than English or Arabic and studies conducted in countries other than those identified above were excluded.

A search strategy with broad criteria was predefined to initially select articles. Based on the review questions, the terms were identified using Population; Intervention; Comparator; Outcome; Time frame (PICOT) (Abbade, Wang, Sriganesh, Mbuagbaw, & Thabane, 2016) to guide the generation of relevant keywords for searching and developing inclusion and exclusion criteria. Table 1 illustrates the PICOT framework guiding.

Table 1. Shows the PICOT Framework guiding the Search of Literature

PICOT-framework	**Keywords**
Population	child, adol*
Place	Bahrain OR Kuwait OR Oman OR Qatar OR Saudi Arabia OR United Arab Emirates OR gulf countries OR Gulf Cooperation Council OR Algeria OR Palestinian Territories OR Comoros OR Djibouti OR Egypt OR Iraq OR Jordan OR Lebanon OR Libya OR Mauritania OR Morocco OR Somalia OR Sudan OR Syria OR Tunisia OR Yemen
Intervention	school AND intervention OR program OR curriculum OR health promotion OR health education
Comparison	-
Outcomes	physical activity OR exercise OR diet OR nutrition OR food choices OR obesity OR overweight OR BMI OR Body Mass Index OR body weight

2.3 Extracting and Charting of Results

Three researchers were involved with screening the search results. One researcher identified the included studies through title and abstract screening, followed by full article screening. The other two researchers checked the full articles to ensure they met the inclusion criteria. Removal of duplications and systematic searching was documented using the reference management software EndNote X9.

The multiple database search initially resulted in 1199 potentially relevant articles. After removal of duplicates, n= 416 articles were further screened. After screening by title, a further 323 articles were excluded and an additional 51 were excluded after the abstract was reviewed. The primary author tabulated all remaining articles (n=42) for full-text review. During the full-text review, further articles were excluded because they were not school-based (n=18); focused on a range of health risk factors without specific focus on prevention or early intervention in overweight and/or obesity (n=5); described methodology only (n = 3); or were not from one of the designated countries (n = 1). Additional papers excluded were abstracts from conference proceedings without full content (n =2). Figure 1 outlines the PRISMA flow diagram for the study selection processes.

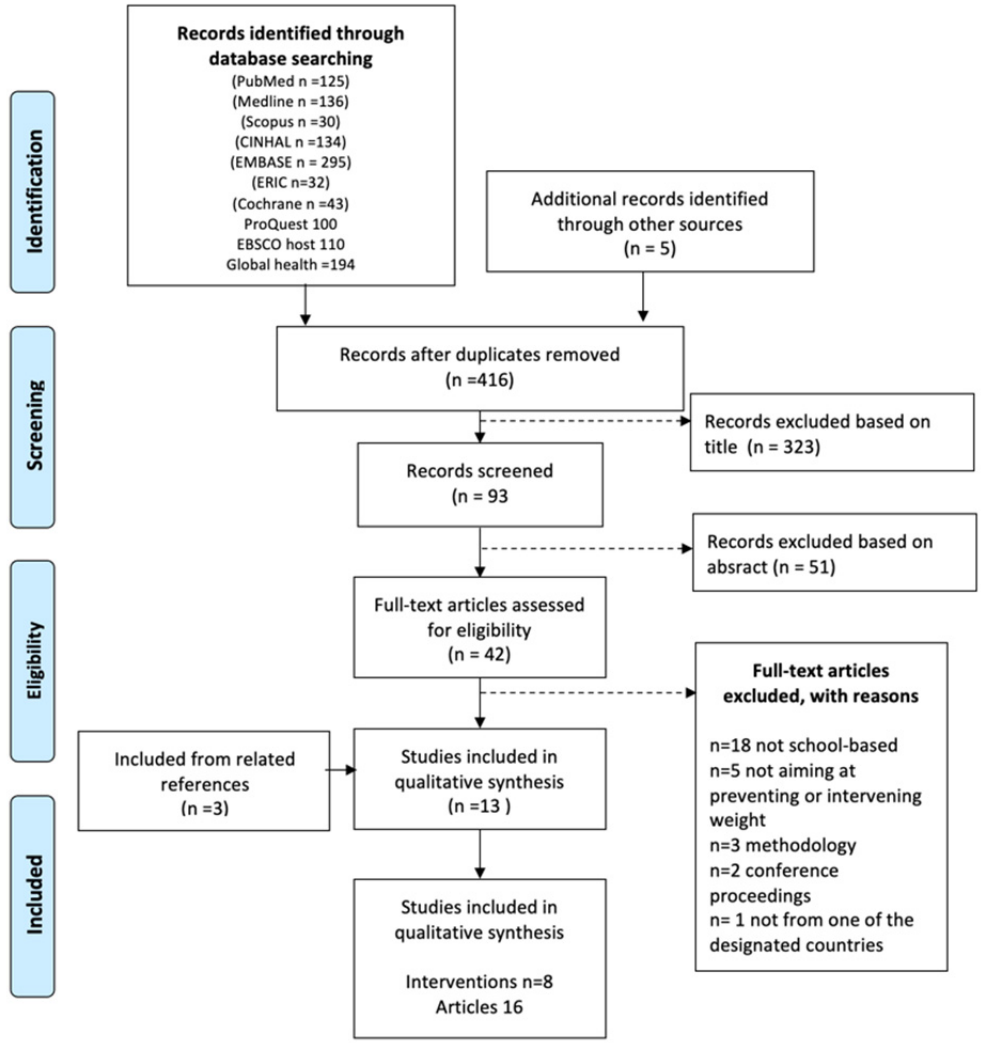

Figure 1. PRISMA flow chart

A descriptive summary of all included studies was extracted from each of the 16 articles that met the inclusion criteria. The characteristics of each study and the relevant key information of this study was reported in accordance with Gerrard's Matrix Method (Garrard, 2017). Extraction fields included authors, year of publication, country, study setting, study design, participants, location of the study conducted (in this case school-based intervention), instrument tools used and study outcomes (Peters et al., 2015). The enablers and barriers of intervention implementation were considered but, out of the 16 included articles, only two studies discussed the feasibility and challenges regarding the implementation of the instrument and/or the intervention. All data were extracted directly into a table by the primary author and checked for completeness and accuracy by all authors. The data was qualitatively examined by their number of participants, duration of intervention and outcomes related to nutrition or physical activity program elements.

In accordance with the Graphic Appraisal Tools for Epidemiology (Ezzati et al., 2018) for intervention and risk version (Jackson et al., 2006), studies were qualitatively assessed and were tabulated accordingly. The components appraised comprised: methodology (recruitment, allocation, maintenance, blinding process and objective measurement) and whether appropriate statistical analysis was employed. The quality appraisal was performed for this scoping review to identify the strength and the weaknesses of all included studies. Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) (Tricco et al., 2018) guidelines were used to inform and summarise in reporting this review. Further analysis was not possible because of the heterogeneity of the study design and differences in outcomes of interest between studies.

3. Results

3.1 Characteristics of Included Studies

Characteristics of included studies are described in detail in Table 2. Of the 16 studies, 10 included quasi-experimental study designs (Awad Elkarim Elfaki et al., 2020; Ben Cheikh et al., 2020; Dendana et al., 2017; Ghammam et al., 2017; Harrabi et al., 2010; Kebaili et al., 2014; Jihen Maatoug et al., 2015a; Jihene Maatoug et al., 2015b; J. M. Maatoug, Harrabi, Delpierre, Gaha, & Ghannem, 2013; Zammit et al., 2016) and the remainder reported randomised controlled trials (Allafi, 2020; A. Bani Salameh et al., 2017; El Ansari, El Ashker, & Moseley, 2010; Habib-Mourad et al., 2020; Habib-Mourad et al., 2014; Kutbi, Al-Jasir, Khouja, & Aljefri, 2019). These 16 articles reported on eight discretely different interventions. Eight of the studies reported on the long-term *Promote Healthy Lifestyles* program intervention in a school in Sousse, Tunisia which promoted increased physical activity and healthy eating in addition to tobacco prevention (Dendana et al., 2017; Ghammam et al., 2017; Harrabi et al., 2010; Kebaili et al., 2014; Jihen Maatoug et al., 2015a; Jihene Maatoug et al., 2015b; J. M. Maatoug et al., 2013; Zammit et al., 2016). Three of these reported on the pilot program that took place in 2007 (Harrabi et al., 2010; Kebaili et al., 2014; J. M. Maatoug et al., 2013) while four reported on the resulting program implemented 2009-2015 (Dendana et al., 2017; Ghammam et al., 2017; Jihene Maatoug et al., 2015b; Zammit et al., 2016). An additional paper by the same authors detailed a specific program for overweight and obese students implemented within the wider program in 2012-2014 (Jihen Maatoug et al., 2015a). A further two of the 16 articles reported on the pilot and later refinement of the *Health-E-PALS* program in Lebanon (Habib-Mourad et al., 2020; Habib-Mourad et al., 2014). The remaining six articles reported on another six separate interventions: One in Sousse Tunisia with primary school aged children (Ben Cheikh et al., 2020), two from Saudi Arabia (Awad Elkarim Elfaki et al., 2020; Kutbi et al., 2019) and one each from Egypt (El Ansari et al., 2010), Jordan (Ayman Bani Salameh et al., 2017), and Kuwait (Allafi, 2020).

Participants were mostly from middle, intermediate or secondary schools with one study involving participants from a primary school (Ben Cheikh et al., 2020). The age of participants ranged from six (Ben Cheikh et al., 2020) to 18 years (A. Bani Salameh et al., 2017). Most of the studies included both male and female participants but one study involved only males (Kutbi et al., 2019) and another only females (Awad Elkarim Elfaki et al., 2020). The majority of intervention-based studies included all students and were focused on specific age and school grade, however two interventions (Ayman Bani Salameh et al., 2017; Jihen Maatoug et al., 2015a) targeted only obese or overweight students. Most interventions selected clusters of classes from the middle and secondary schools, the maximum number of students involved ranged from 148 (Kutbi et al., 2019) to 4275 (Jihene Maatoug et al., 2015b), and the intervention duration varied from six weeks (Allafi, 2020) to a maximum of three years (Dendana et al., 2017; Ghammam et al., 2017).

3.2 Summary of Interventions

A team of researchers in Tunisia conducted the *School based intervention to promote healthy life styles* among school children in Sousse in 2007. This pilot study was reported on by Harrabi et al. (2010); J. M. Maatoug et al. (2013) and Kebaili et al. (2014). Harrabi et al. (2010) described their aim to evaluate the effect of a school cardiovascular disease (CVD) risk factors prevention program on the knowledge and intentions of more than 2,000 students aged between 12 -16 years (Harrabi et al., 2010). The intervention was implemented in two public schools in Ezzahra and Khzemain. The intervention consisted of class-room based education sessions focusing on tobacco use, physical activity and healthy diet and interclass sport tournaments. These were delivered by the research team, teachers and school doctors. Nutrition knowledge and intentions improved for all students and was significantly higher in the intervention group (Harrabi et al., 2010). Additionally, while there was a statistically significant increase in physical activity for both groups, it was significantly higher in the intervention group. However, there was no change in BMI for either the control or intervention group. J. M. Maatoug et al. (2013) reported in more detail a significantly higher post-test knowledge and behavioural intention in the interventional group. They further described the same study with the aim of identification of predictors of health diet and physical activity patterns finding that younger children, those of higher socioeconomic status and those who already ate well and undertook physical activity were predictive of positive behaviours and intentions (J. M. Maatoug et al., 2013). Kebaili et al. (2014) also reported the same pilot study focusing on the nutrition survey detailing the significant pre-and post-survey differences in knowledge, intention and behaviours for the intervention group.

The Tunisian researchers then undertook a longer and more comprehensive intervention with more than 4,000 children aged 11 to 16 years in Sousse undertaking baseline assessment in 2009-2010, delivering a three year intervention from 2011 to 2013 with post intervention assessment in 2013-2014 and a one year follow-up in 2015 (Dendana et al., 2017; Ghammam et al., 2017; Jihene Maatoug et al., 2015b; Zammit et al., 2016). The intervention included: training student leaders to motivate peers and help organise educational events and media

(e.g., posters, dances) for peers, parents, and teachers; interactive classroom-based lessons with teachers; and environmental change such as increased afterschool and interschool sports and encouraging community shops to stock healthier snack foods that children were rewarded for purchasing or encouraging the owners of snack stores to switch the usual sweetened snacks with healthy alternatives(Dendana et al., 2017; Ghammam et al., 2017; Jihene Maatoug et al., 2015b). A number of validated self-complete surveys measuring knowledge and self-efficacy were used to assess the level of behavioural changes associated with the effect of interventions evaluated in these Tunisian studies (Dendana et al., 2017; Ghammam et al., 2017; Jihene Maatoug et al., 2015b; Zammit et al., 2016). In addition, biometric measures were used to assess the impact of various interventions on weight and other body composition (Dendana et al., 2017; Ghammam et al., 2017; Jihene Maatoug et al., 2015b; Zammit et al., 2016). Dendana et al., (2017) and Maatoug et al. (2015b) reported that the post intervention data showed a statistically significant increase in fruit and vegetable consumption ($p = 0.026$) but decreased proportion of pupils who were obese which did not reach statistical significance in the intervention group. On the other hand, a statistically significant increase in proportion of pupils with obesity ($p = 0.001$) and those with low fruit and fruit and vegetable consumption ($p = 0.001$) were seen in the control group. A one year follow-up indicated some continuing positive effects but a drop-off in improvement in fruit and vegetable consumption and body weight concluding that interventions should be maintained (Ghammam et al., 2017). It was posited that the Tunisian revolution and the lack of outdoor security resulted in the lower physical activity recorded (Ghammam et al., 2017). A smaller follow-up of a group of 204 students in middle school reported by Zammit et al. (2016) concluded that the intervention had limited sustainable effects on nutrition and physical activity.

Jihen Maatoug et al. (2015a) conducted another study in 2012-2014 (alongside the larger Sousse intervention) involving more than 500 overweight and obese children to investigate the challenges and results of school based interventions to manage excess weight (Jihen Maatoug et al., 2015a). The intervention group of more than 300 overweight and obese children participated in a one year intervention consisting of an exercise program and small group sessions with a dietician focusing on healthy eating; with a psychologist focusing on self-esteem; and with a medical doctor focusing on snacking. Individual 3-monthly sessions with medical staff and individual dietary advice for obese children were provided. The children were assessed at pre-intervention, post-intervention and after 4 months. A standardized, pretested self-administered questionnaire in Arabic was used to evaluate physical activity behaviors and fruit and vegetable consumption of schoolchildren. The questionnaire was administered in schools in the presence of trained medical doctors to standardize and assist the students in filling out the questionnaires and to define terminology. The authors collected biometric measurements (i.e. height and weight) of the students. Body weight was recorded to the nearest 0.1 kg by using a portable electronic scale taken with participants wearing a light layer of clothing. Data on height were measured with the participants standing barefoot and recorded to the nearest 0.5 cm. The BMI of the intervention group reduced significantly at the 4 month follow up point. The authors discussed their perception that the students did not show a larger decrease in BMI as they were unmotivated, Tunisia contains fewer healthy food choices and more unhealthy choices, the Tunisian school environment does not promote or provide infrastructure for physical activity and that the parents valued academic achievement above weight loss.

Ben Cheikh et al. (2020) conducted a quasi-experimental study in Tunisia to study the effect of a school based nutrition promotion intervention on over 500 hundred primary school children aged 6 to 12 years (Ben Cheikh et al., 2020). The intervention involved two schools with one receiving an intervention and one acting as the control, promoting of the reduced consumption of unhealthy morning snacks. The 6 month intervention consisted of educational activities for children and parents (e.g. dietician led sessions, peer training of student leaders to motivate peers, cooking workshop, competitions, parent Facebook group and SMS messages to parents). Ben Cheikh and colleagues also implemented a set of interventions which comprised role modelling; a drawing competition, writing, poetry and chef on the theme of healthy and balanced diet; provision of healthy snacks for children such as fruits and vegetables in the school canteen and limited accessibility at least in primary school to unhealthy products, mainly trans-fat, high fat and high salted food: the school canteen, the street vendor and the small stores around school were encouraged to sell healthy snacks: school children who chose the healthy snacks were rewarded with incentive stickers, which they collected for a prize: two SMS messages per months were sent to parents which explain the importance of parents' implication in promoting a healthy diet (Ben Cheikh et al., 2020). The main outcome was measured with the use pretested self-administered questionnaires in Arabic which was administered to parents and school children in both intervention and control schools. The self-administered questionnaire for parents included the sociodemographic characteristics and eating habits of their children whereas the questionnaire for children was given in classes in the presence of trained medical doctors to assist children filling in the questionnaires. It has included snacks consumed the day before the survey and its composition. The results revealed that the consumption of morning snacks decreased significantly and that the consumption of healthy foods increased after the intervention.

Habib-Mourad et al. (2014) reported on the *Health-E-PALS ('Intervention to promote Healthy Eating and Physical Activity in Lebanese School children')* intervention to investigate the effect of health eating and physical activity among school children aged 9 to 11 years in Lebanon. The *Health-E-PALS* intervention program consisted of: weekly nutrition sessions in classes run by nutritionists; family involvement via meetings, health fairs and information and recipes sent home with food samples; and promotion of health food at the school shop and in lunchboxes from home. The intervention group, compared to the control group, had significantly higher knowledge and self-efficacy and reported less purchasing of unhealthy foods. However, this pilot study also reported no significant difference in physical activity behaviours or change was observed in BMI between intervention and control groups. The lack of change in BMI is likely attributable to insufficient duration (12 weeks) between pre-test and post-test. In a two trial study conducted by the same group of investigators Habib-Mourad et al. (2020) evaluated the effectiveness of a school-based intervention delivered by a non-nutrition specialist (trained school teachers) compared to a nutritionist in over 2200 students aged 9–11 years across 60 schools in Lebanon (Habib-Mourad et al., 2020). In this study, two trials of the same school-based intervention using the same intervention package were delivered over one year, one by nutritionists to 30 schools and another by trained school teachers to another 30 schools. Dietary behaviours and physical activity were the main focus of the intervention. In both trials, the 60 selected schools were randomized to intervention or control groups; students in both groups were compared at post-test on knowledge and self-efficacy scores, as well as dietary and physical activity behaviours. In addition to behavioural interventions, Habib-Mourad and colleagues implemented environmental changes including role modelling of significant others and availability of healthy choices at home and school (Habib-Mourad et al., 2020; Habib-Mourad et al., 2014). In both studies, a food service intervention targeted the school shops, checking the lunch boxes sent by the families, role modelling of significant others and availability of healthy choices at home and school were the main environmental factors addressed in both groups as interventions. Parents contributed to the success of the Health-E-PALS intervention by ensuring the availability and accessibility of healthier food options at home, and through role modelling. Parents and teachers involved in interventions served as role models for students and positively impacted study outcomes through continued positive reinforcements via praise and tokens (Habib-Mourad et al., 2020). Anthropometric measurements including height, weight and waist circumference were taken at both time points (pre and post intervention) using standardized techniques and calibrated equipment. Self-administered questionnaires on determinants of behavioural change, eating and physical activity habits were administered to the students in both groups at baseline and post intervention. Focus group interviews were conducted in intervention schools at the end of the study. For students in both intervention and control schools, a baseline assessment (pre-test) was conducted a week prior to the start of the intervention, followed by another assessment one week after the completion of the intervention (post-test). Both assessments took place in the classroom. The questionnaire used was designed to collect data on indication of dietary physical activity, and sedentary behavioural habits. It was not designed to measure dietary intake, physical activity, or sedentary behaviours (Habib-Mourad et al., 2020). A statistically significant improvement in knowledge and self-efficacy scores was observed in intervention versus the control group. An improvement in dietary behaviours was observed with the intervention but physical activity did not increase for either group. The lack of improvement in physical activity among the students could be attributed to the limited accessibility to extracurricular activities, as a result of budget constraints, homework overload or the lack of safe and free places for spontaneous physical activity or play.

Ayman Bani Salameh et al. (2017) assessed the effectiveness a 12 weeks school-based educational preventative program for type 2 diabetes mellitus in Jordanian overweight and obese male and female adolescents aged 12-18 years in two unisex high schools (Ayman Bani Salameh et al., 2017). This study in Irbid City was a single-blinded randomised controlled trial which enrolled about 400 visibly overweight or obese adolescents in two unisex high schools and randomly allocated them into intervention and control groups. The 12-week educational program consisted of group information sessions for an average of five students and their parents. The intervention was based on the Australian *Swap It Don't Stop It* program with an individual 12 week guide providing diet and physical activity recommendations and shopping advice for parents. Students were reminded by teachers to fast for eight hours prior to data collection. Physiological measurements such as weight and height were measured using a standardized protocol and calibrated equipment. The authors measured weight of students with each clothed, but without shoes, on a digital scale whereas height in centimetres was measured with the participant barefoot using standard scale on the wall and a ruler on the head (stadiometer). Body mass index (BMI) was calculated using the anthropometric measures and classified according to the CDC standard charts accounting for gender, age in years and months, height in metres, and weight in kilograms (CDC, 2009). Peripheral blood glucose levels of participants were estimated with the use of glucometers. Weekly diet and exercise monitoring records were checked bi-weekly. School-based early preventative intervention effectively reduced weight and fasting blood glucose in Jordanian at-risk adolescents. There was a statistically significance difference between pre and

post-intervention weight and fasting blood glucose between the two groups. The control group gained weight and increased their fasting blood glucose level while the intervention group lost weight and decreased their fasting blood glucose level.

Awad Elkarim Elfaki et al. (2020) evaluated the effect of school-based healthy lifestyle intervention on obesity with 565 female students aged 12–15 years randomly selected from four schools in Jizan City in Saudi Arabia. The two intervention schools promoted healthy food choices and physical activity over a six month period using: a one day counselling session; health education classes; daily before-school exercise classes; educational materials for parents; and an individual intervention plan for girls who were overweight or obese. The World Health Organization (WHO) STEPS survey instrument was used to measure the effectiveness of the intervention and to assess outcomes of the study. The WHO STEPS covers three different levels of steps of risk factor assessment. The authors used only two of the three WHO STEPS surveys to evaluate the effectiveness of the intervention. STEP-1 which included a questionnaire covering the basic demographic information and behavioral risk factors (dietary patterns, physical activity) of participants and STEP-2 which covered physical measurements (anthropometric measurements) were employed. Anthropometric measurements such as height and weight were taken using standardized protocols and calibrated equipment. Weight was measured to the nearest 0.1 kg in light indoor clothing and with bare feet or stockings while height was measured without shoes and recorded to the nearest 0.5 cm using a calibrated weighing scale. This revealed that the intervention group, compared with the control group, demonstrated a significant increase in walking, moderate and vigorous physical activity and reduction in consumption of fast food and soft drinks. Additionally, there was a significant reduction in the prevalence of obesity in the intervention group and an increase in obesity in the control group.

Kutbi et al. (2019) conducted a cluster randomized controlled trial of 184 male adolescents aged 10 to 15 years to evaluate the impact of an educational program in Jeddah, Saudi Arabia on physical activity, consumption of healthy foods, and anthropometric measurements (Kutbi et al., 2019). The intervention was a two-month school-based program providing one weekly session which was either a health education session, a group counselling session, a group presentation developed by the students or a discussion of student presentations. The first month discussed healthy dietary behaviours and the second discussed physical activity comprising one weekly session which was either a 60-minute health education session, a group counselling session, a 5-10 minute presentation developed by the students or a discussion of student presentations. Anthropometric measurements (i.e. weight) of study participants were assessed using standardized protocol and calibrated equipment. A growth chart recommended by the Saudi Ministry of Health was used to plot the weight of the adolescents and then calculate BMI for adolescents according to the international definition of children's overweight and obesity developed by Cole, Bellizzi, Flegal, and Dietz (2000). The researchers measured and calibrated physical activity using the metabolic equivalent equation recommended by the compendium of physical activity 2011. By this, participant's activity was converted into metabolic equivalents in minutes per day for ease of analysis and comparison to standards. Dietary habits and sedentary behaviours were measured as recommended by healthy food pyramids and the Canadian Physical Activity and Sedentary Behavior Guidelines respectively. The intervention increased the percentage of students who: participated in sufficient physical activity; ate more fruit and vegetables; and ate less fast food. However, there were no statistically significant effects between the intervention and control groups. The authors pointed out that the adolescents were in the age of physiological growth and development with a natural increase in the weight and height and this could explain the lack significant difference anthropometric parameters seen between the intervention and control groups.

An experimental study conducted by Allafi (2020) assessed the effectiveness of a combined pedometer-feedback and rewards versus feedback alone on increasing physical activity in 225 male and female students aged 9–11 years who attended six different public schools in Kuwait City, Kuwait (Allafi, 2020). The students were randomly assigned to three different groups during school physical activity classes,:–feedback, feedback with rewards, and control group. Participants in the feedback group received information about the function of pedometer only whereas the feedback plus reward group received information about the function of the pedometer and were asked for a 3000 counts milestone to receive ten stickers. The control group participants did not receive any information about the function of the pedometer. Participants were given pedometers at the beginning of every session. All pedometers were set to zero and participants were instructed to keep wearing them during the whole session (50 minutes). Pedometer counts were taken from all participants after five physical education classes. Participant's body mass and height were measured without shoes using a Hanson electronic scale and a tape measure attached to a vertical wall, respectively. Each student's BMI was then computed. The study results were similar for male and female students and revealed that there was as significant increase in number of steps between students who were taught about the pedometer and the control group. A significantly higher number of steps were taken by the student who were also given a rewards indicating that encouraging children with rewards will increase their physical activity levels.

El Ansari et al. (2010) evaluated the effectiveness of a physical activity intervention programme which comprised an after school one hour of moderate exercise three times a week for a period of three months in a randomized study of 160 secondary male and female school pupils aged approximately 15 years in one school in Mansoura, Egypt (El Ansari et al., 2010). These sessions were additional to the usual two physical activity classes taken by both the intervention and the control groups. The researchers assigned each participating pupil with a data capturing sheet where research assistants recorded the pupil's anthropometric and physiological parameters at baseline and after three months and each of the measurements were obtained three times on the same day to ensure accuracy. Anthropometric evaluation comprised three parameters–weight and height, BMI status and body fat. Weight and height was measured using a digital weight and height scale. Height was measured to the nearest 0.1 cm while the participants stood barefooted, and body weight was measured to the nearest 0.1 kg with participants wearing light clothing and no footwear. The BMI status was estimated from weight and height using Metric BMI Formula [BMI (kg/m^2) = weight in kilograms/the squared height (m^2)]. For measurement of body fat, skin folds thickness were measured using The Harpenden Skinfold Caliper and the 3-Site formula was used to measure skin folds. Body density was calculated according to standard formulae and body fat percentage was described in line with the American College of Sports Medicine. The values for three sites of the left side of the body were obtained in millimetres. The authors reported a statistically significant increase in BMI after three months follow-up for both boys and girls in the control group. The control pupils displayed increases (worsening) across all the anthropometric and physiological parameters that were examined. However, these increases were only statistically significant for BMI in boys, and BMI and diastolic blood pressure (DBP) in girls. Despite that lack of statistical significance in many parameters, it is noteworthy that for all the parameters and for both genders, the differences for the control pupils were positive (*i.e.*, the control pupils got worse) (El Ansari et al., 2010).

Table 2. Characteristics of the included studies

-Author, Year, Name of Cohort/Study, Citations, Country	Study Design, Patient Characteristics	Key Intervention Characteristics	Outcomes
Zammit et al. (2016), Tunisia	**Age:** Intervention: 12.39 ± 0.68 Control: 12.4 ± 0.72 **Sample:** school- children enrolled in middle schools **Sample size:** Intervention (n=105) Control (n = 99) Total = 205 **Study Design: Study Design:** Quasi-experimental **Behavioural intervention** **Follow up study**	**Duration of intervention:** 3 years **Follow-up:** 1 year **Teacher training:** None reported **Parent involvement:** None reported **Digital component:** None reported **Behavioural intervention:** tobacco prevention, physical activity and healthy eating promotion **Other:** questionnaire administered in presence of a trained medical doctor **Environmental factors:** None reported **Instruments use:** - Standardized, pretested questionnaire - Anthropometric measurements	• **Intervention group Pre vs post** Diet (fruit and veg.): increase 15.2% (p= 0.017) Recommended PA: not significant • **Control group Pre vs post** Diet (fruit and veg.): increase 22.7% (p= 0.002) Recommended PA: not significant • **Control vs Intervention group** not reported *BMI* not reported
Ghammam et al. (2017), Tunisia	**Age: 11-16 years old** Intervention: NR Control: NR **Sample:** Grade 7 and 9 students **Sample size:** Intervention (n=2000) Control (n = 2000) Total = ~4000 **Study Design:** Quasi-experimental **Behavioural intervention** **Follow up study** quasi experimental	**Duration of intervention:** 3 years **Follow-up:** 1 year **Teacher training:** None reported **Parent involvement:** None reported **Digital component:** None reported **Behavioural intervention:** tobacco prevention, physical activity and healthy eating promotion **Other:** questionnaire administered in presence of a trained medical doctor **Environmental factors:** None reported **Instruments use:** - Standardized, pretested questionnaire - Anthropometric measurement	• **Intervention group Pre vs post** ***Weight mixed*** Among normal weight: p = .024 Among overweight : p= .036 Among obese : p=.515 ***Behaviour Assessment:*** Diet (fruit and veg.): p= 0.026 Recommended PA: p= 0.010 • **Control group Pre vs post** ***weight*** -Among normal weight: p= .016 **(weight increase)** -Among overweight : p= .602 -Among obese **(weight increase)**: p=<.001

	Behavioural intervention **Follow up study**		***Behaviours Assessment:*** Diet (fruit and veg.): p= 0.001 Recommended PA: p= NS • **Control vs Intervention group** not reported
Dendana et al. (2017), Tunisia	**Age: 11 – 16 years** Intervention: NR Control: NR **Sample:** Grade 7 and 9 students **Sample size:** Intervention (n=2074) Control (n = 1929) Total = 4003 **Study Design:** *quasi-experimental* Behavioural and environmental change intervention Follow up study	**Duration of intervention:** 3 years **Follow-up:** 1 year **Teacher training:** None reported **Parent involvement:** None reported **Digital component:** None reported **Behavioural intervention:** Health promotion and training groups leaders to (*physical activity and healthy diet promotion, tobacco control*) **Other:** questionnaire self-administered **Environmental factors:** *Encouraging the owners of snack stores to switch the usual sweetened snacks with healthy* *alternatives* **Instruments use:** - Standardized, pretested self-administered questionnaire - Anthropometric measurement	• **Intervention group Pre vs post** Low Diet (fruit and veg.): p=0.026 Low PA (>10 min/day walk): NS BMI: NS • **Control group Pre vs post** Low Diet (fruit and veg.): p= 0.001(increased low intake of fruit and veg.) Low PA (>10 min/day walk): NS BMI: ***increase*** in obesity (p=0.001) • **Control vs Intervention group** Not reported
Jihene Maatoug et al. (2015b), Tunisia	**Age:** 11 – 16 years **Sample:** Grade 7 and 9 students **Sample size:** Intervention (n=2074) Control (n = 1929) Total (n = 4003) **Study Design:** *quasi-experimental* Behavioural intervention	**Duration of intervention:** 3 years **Follow-up:** **Teacher training:** None reported **Parent involvement:** None reported **Digital component:** None reported **Behavioural intervention:** Promotion of adopting healthy nutrition and doing the recommended physical activity **Other:** questionnaire self-administered **Environmental factors:** None reported **Instruments use:**	• **Intervention group Pre vs post** ***weight*** -Among normal weight: p= .03 -Among overweight : p= .03 -Among obese : p= .51 -Effect on excess weight: p=.02 **(***protective factors against excess weight***)** ***-Behaviours Assessment:*** Diet (fruit and veg.): p= 0.03 Recommended PA: p= 0.031

	Follow up study	Standardized, pretested questionnaire Anthropometric measurement	**Control group Pre vs post** ***weight*** --Among normal weight: p= .02 -Among overweight: p= .58 -Among obese : p=<.001 -Effect on excess weight: **NS** ***-Behaviours Assessment:*** Diet (fruit and veg.): p= 0.01 Recommended PA: p= **NS** • **Control vs Intervention group** • Not measured
Habib-Mourad et al. (2014), Lebanon	**Age:** 9 – 11 years **Sample:** Grade 4 and 5 students in 4 private and 4 public schools **Sample size:** Intervention (n= 193) Control (n = 181) Total (n = 387) **Study Design:** *sequential explanatory* *mixed method* Behavioural and environmental change intervention Follow up study	**Duration of intervention:** 3 months **Follow-up:** None reported **Teacher involvement:** Role modelling **Parent involvement:** Role modelling, accessibility and availability of healthy choices **Digital component:** None reported **Behavioural intervention:** interactive classroom learning, family programmes and healthy food choices (*Promotion* *increasing consumption of fruits and vegetables, favouring healthy over high energy dense snacks and* *drinks, increasing the habit of having breakfast daily, in-* *creasing moderate-to-vigorous physical activity* *and decreasing overall sedentary behaviour*) **Other:** none reported **Environmental factors:** *Family programs and interventions on school shops and lunch boxes to create an environment to promote healthy choices.* **Instruments use:** Focused group discussions	• **Intervention group Pre vs post** Not reported • **Control group Pre vs post** Not reported • **Control vs Intervention group** Recommended PA: NS Dietary habits: not conclusive Knowledge score:p<0.001 Self-efficacy score : p<0.001 BMI: NS **Qualitative results:** Increased knowledge, skills and self-confidence in preparing and enjoying healthy food.

		- Adopted questionnaire - Anthropometric measurement	
Habib-Mourad et al. (2020), Lebanon	**Age:** 9 – 11 years **Sample:** Cluster of middle school students **Sample size:** Intervention (n= 699) Control (n = 701) Total (n = 1400) **Study Design:** *Two Randomized control trials in one study* Behavioural and environmental change intervention Follow up study	**Duration of intervention:** 1 year **Follow-up:** None reported **Teacher involvement:** Role modelling and teacher centred program **Parent involvement:** Role modelling, accessibility and availability of healthy choices **Digital component:** None reported **Behavioural intervention:** interactive classroom learning, family programmes and healthy food choices (*Promotion* *increasing consumption of fruits and vegetables, favouring healthy over high energy dense snacks and* *drinks, increasing the habit of having breakfast daily, in-* *creasing moderate-to-vigorous physical activity* *and decreasing overall sedentary behaviour*) **Other:** Team of nutritionist involved in one arm of trial **Environmental factors:** *Family programs and interventions on school shops and lunch boxes to create an environment to promote healthy choices.* **Instruments use:** - Pretested questionnaire - No anthropometric measurement	**Knowledge score** Nutritionist OR= 2.97, 95%CI (2.68; 3.68) Teacher OR= NS **Self-efficacy score** Nutritionist = OR= 2.00, 95%CI (1.45; 2.50) Teacher = NS **-Dietary habits** Nutritionist: Significant Teacher: NS **Physical activity** Nutritionist: NS Teacher: NS
Kebaili et al. (2014), Tunisia	**Age:** 12 – 16 years **Sample:** Middle school students **Sample size:** Intervention (n= 1247) Control (n = 1091) Total (n = 2338) **Study Design:** Quasi-experimental	**Duration of intervention:**3 months **Follow-up:** None reported **Teacher involvement:** None reported **Parent involvement:** None reported **Digital component:** None reported **Behavioural intervention:** Healthy nutrition promotion (importance of balanced diet, breakfast, dietary pyramid) **Other:** None reported **Environmental factors:** None reported	• **Intervention group Pre vs post** significant knowledge, intentions, and behaviours changes pre to post test • **Control group Pre vs post** No significant knowledge, intentions, and behaviours changes pre to post test • **Control vs Intervention group** Intervention group showed a significant improvement than in the control group at

	Behavioural intervention **Follow up study**	**Instruments use:** - Validated self-administered questionnaire - No anthropometric measurement	post-assessment
Harrabi et al. (2010), Tunisia	**Age:** 12 – 16 years Mean (13.4± 1.1) **Sample:** 4 Public secondary school **Sample size:** Intervention (n= 1965) Control (n = 1737) Total (n = 2338) **Study Design:** quasi experimental **Behavioural intervention** **Follow up study**	**Duration of intervention:**3 months **Follow-up:** None reported **Teacher involvement:** None reported **Parent involvement:** None reported **Digital component:** None reported **Behavioural intervention:** *Cardiovascular disease risk factors prevention curriculum* Health promotion (60 min) on -tobacco prevention, -physical activity -healthy eating **Other:** None reported **Environmental factors:** None reported **Instruments use:** - Pre-tested self-administered questionnaire - Anthropometric measurement	• **Intervention group Pre vs post** Diet (fruit and veg.): NS Recommended PA: p<0.001 BMI = NS • **Control group Pre vs post** Diet (fruit and veg.): p= 0.03(increase of fruit and veg) Recommended PA (>30 min/day): p<.001 BMI = NS • **Control vs Intervention group** Diet (fruit and veg.): NS Recommended PA (>30 min/day): p<.001 **BMI** = NS
J. M. Maatoug et al. (2013), Tunisia	**Age:** 12 – 16 years Mean (13.4 ± 1.1) **Sample:** Middle school **Sample size:** Intervention (n = 1247) Control (n = 1091) Total (n = 2338) **Study Design:** quasi experimental	**Duration of intervention:** 1 academic year **Follow-up:** None reported **Teacher involvement:** None reported **Parent involvement:** None reported **Digital component:** None reported **Behavioural intervention:** Promotion on healthy nutrition and physical activity for at least 30 min a day/5days/week and a sedentary activity for less than 2 hour per day **Other:** None reported	• **Intervention group Pre vs post** Intention of Diet (fruit and veg.): p<0.001 Behaviour of Diet (fruit and veg.): p<0.001 Intention of Recommended PA (>30 min/day): p<.001 Behaviour of Recommended PA (>30 min/day): p<.001 • **Control group Pre vs post** Intention of Diet (fruit and veg.): NS

	Behavioural intervention **Follow up study**	**Environmental factors:** None reported **Instruments use:** - Pre-tested self-administered questionnaire - No anthropometric measurement	Behaviour of Diet (fruit and veg.): p= 0.03 Intention of Recommended PA (>30 min/day): NS Behaviour of Recommended PA (>30 min/day): NS • **Control vs Intervention group** Not reported
Awad Elkarim Elfaki et al. (2020), Saudi Arabia	**Age:** 12 – 15 years **Sample:** Intermediate Schools (grades 7-9), all female students **Sample size:** Total (n = 565) **Study Design:** quasi experimental **Behavioural intervention** **Follow up study**	**Duration of intervention:** six months period **Follow-up:** None reported **Teacher involvement:** None reported **Parent involvement:** None reported **Digital component:** None reported **Behavioural intervention:** One-day counselling session (lectures, open discussions, role-playing, games, and questions) **-Health education classes** (for healthy eating and physical activity) **- physical activity** (morning sessions) **Other:** None reported **Environmental factors:** None reported **Instruments use:** - Pre-tested self-administered questionnaire - Anthropometric measurement	• **Intervention group Pre vs post** Diet (fruit and veg.): p<0.001 PA (>10 min/day walk): p<.001 Weight : NS BMI: NS • **Control group Pre vs post** Diet (fruit and veg.): NS PA (>10 min/day walk): NS Weight : NS BMI: increase in obesity (p=0.015) • **Control vs Intervention group** Not reported
Jihen Maatoug et al. (2015a), Tunisia	**Age:** 11 – 16 years Intervention = 13.1 ± 0.96 Control=13.5 ± 0.89 **Sample:** Grades 7 and 8 (overweight and obese) students **Sample size:**	**Duration of intervention:** six months period **Follow-up:** 4 months **Teacher involvement:** None reported **Parent involvement:** None reported **Digital component:** None reported **Behavioural intervention:** The “Contrepoids” program for 1 year;	• **Intervention group Pre vs post** Diet (daily calorie **decrease**) : p<0.001 Recommended PA (>30 min/day): p= NS BMI Z-score = <0.001 BMI =NS • **Control group Pre vs post**

	Intervention (n = 317) **Control (n = 268)** Total (n = 585) **Study Design:** quasi experimental **Behavioural intervention** **Follow up study**	1 hour of Counselling, (Healthy eating and regular physical activity); Twice a week physical activity **Other:** None reported **Environmental factors:** None reported **Instruments use:** - 24 hours food recall -3-day PA recall - Anthropometric measurement	Diet (daily calorie **increase**): p<0.001 Low Recommended PA (>30 min/day): p<0.001 BMI Z-score= p<0.001 (*increased BMI*) BMI = p<0.001*(increased BMI*) • **Control vs Intervention group** Not reported
Ben Cheikh et al. (2020), Tunisia	**Age:** 6 – 12 years Intervention = 8.89 ±1.6 years Control = 8.55 ±1.7 years **Sample:** first–sixth grade children and their parents (primary school) **Sample size:** Intervention (n = 9) Control (n = 11) Total (n = 20) **Study Design:** quasi experimental **Behavioural intervention** **Environmental change intervention** **Follow up study**	**Duration of intervention:** five months **Follow-up:** Not reported **Teacher involvement:** None reported **Parent involvement:** Role modelling and healthy dietary choices **Digital component:** None reported **Behavioural intervention:** Promotion of healthy eating habits only **Other:** None reported **Environmental factors:** (*Provision of healthy snacks and limited accessibility snacks*) **Instruments use:** - pre-tested self-administered questionnaire (parents and children) - Anthropometric measurement	• **Intervention group Pre vs post** Diet (decreased morning snacks) : p=0.009 • **Control group Pre vs post** Diet (decreased morning snacks) : p=0.009 • **Control vs Intervention group** Not reported
Kutbi et al. (2019), Saudi Arabia	**Age:** 10 – 15 years Mean = 14.45±2.32 years **Sample:** Male adolescents **Sample size:** Intervention (n = 79) Control (n = 69) Total (n = 148)	**Duration of intervention:** 2 mons **Follow-up:** 2 months **Teacher involvement:** None reported **Parent involvement:** Role modelling and healthy dietary choices **Digital component:** None reported **Behavioural intervention:** -Health education consumption of healthy diet and doing regular PA	• **Intervention group Pre vs post** Not reported • **Control group Pre vs post** Not reported • **Control vs Intervention group** PA (weeks, minutes)= NS BMI= NS

	dropout rate 18.8% **Study Design:** *Cluster Randomized controlled trial* **Behavioural intervention** **Environmental change intervention** **Follow up study**	(2 weeks), -counselling (2 week) -Presentation about healthy life style and discussion (2 weeks each) **Other:** None reported **Environmental factors:** none reported **Instruments use:** - Validated self-administered questionnaire - Anthropometric measurement	
Allafi (2020), Kuwait	**Age:** 9 – 11 years **Sample:** Students from six public elementary schools **Sample size:** Boys (n = 110) Girls (n = 115) Total (n = 225) **Study Design:** *Randomized controlled trial* **Behavioural intervention (Physical activity)** **Follow up study**	**Duration of intervention:** 6 weeks **Follow-up:** 6 weeks **Teacher involvement:** None reported **Parent involvement:** None reported **Digital component:** None reported **Physical activity intervention:** Rewards for walking And its impact on increasing children's physical activity **Other:** None reported **Environmental factors:** none reported **Instruments use:** -pedometers (measures number of steps) -Anthropometric measurements	• **Intervention group Pre vs post** Not reported • **Control group Pre vs post** Not reported • **Control vs Intervention group** PA (Number of steps) : Control mean (lowest steps)vs Feedback vs Feedback & reward (highest steps) = p<0.001 BMI : not reported
Ayman Bani Salameh et al. (2017), Jordan	**Age:** 12 – 18 years Mean (15.3 years) **Sample:** overweight or obese adolescents/students **Sample size:** Intervention (n = 205) Control (n = 196) Total (n = 401) **Study Design:** *Single blinded Randomized controlled trial*	**Duration of intervention:** 3 months **Follow-up:** 3 months **Teacher involvement:** None reported **Parent involvement:** None reported **Digital component:** None reported **Behavioural intervention:** 12 week program Promotion on healthy nutrition and physical activity **Other:** None reported **Environmental factors:** none reported **Instruments use:** -Anthropometric measurements	• **Intervention group Pre vs post** P value not reported • **Control group Pre vs post** P value not reported • **Control vs Intervention group** Weight (kg): p<0.001

	Behavioural intervention **Follow up study**	- Blood glucose measurements	
El Ansari et al. (2010), Egypt	**Age (mean±SD)** Intervention (15.7±1.8 years) Control (15.4±1.6 years) **Sample:** Secondary school pupils **Sample size:** Intervention (n = 80) Control (n = 80) Total (n = 165) **Study Design:** *Randomized controlled trial* **Behavioural intervention (Physical activity)** **Follow up study**	**Duration of intervention:** 3 months **Follow-up:** 3 months **Teacher involvement:** None reported **Parent involvement:** None reported **Digital component:** None reported **Behavioural intervention:** 12 week physical activity only: (30 minutes two sessions per week with moderate intensity) **Other:** None reported **Environmental factors:** none reported **Instruments use:** -Anthropometric measurements - Physiologic measurements	• **Intervention group Pre vs post** P value not reported • **Control group Pre vs post** P value not reported • **Control vs Intervention group** BMI(both girls and boys): $p<0.05$ Body fat(both girls and boys): $p<0.05$

RCT: Randomised controlled trials; NS: Not Significant, PA: physical activity

3.3 Quality Appraisal of Included Articles

3.3.1 Randomisation

To assess the strength and weaknesses of the included studies, the methodological and statistical analysis was tabulated in a form of quality appraisal (see Tab 3) (Jackson et al., 2006). Most studies (n=16) recruited their eligible participants or schools using random or randomly stratified proportional sampling (Allafi, 2020; Awad Elkarim Elfaki et al., 2020; Ayman Bani Salameh et al., 2017; Ben Cheikh et al., 2020; Dendana et al., 2017; El Ansari et al., 2010; Ghammam et al., 2017; Habib-Mourad et al., 2020; Habib-Mourad et al., 2014; Harrabi et al., 2010; Kebaili et al., 2014; Kutbi et al., 2019; Jihen Maatoug et al., 2015a; Jihene Maatoug et al., 2015b; J. M. Maatoug et al., 2013; Zammit et al., 2016) and two studies only included obese or overweight participants (Ayman Bani Salameh et al., 2017; Jihen Maatoug et al., 2015a).

Table 3. Quality appraisal

Author citations	**RECRUITMENT** **(were participants representative)**	**ALLOCATION** **(how were participants allocated to control and intervention? Randomly?)**	**M) MAINTENANCE** **(did participants remain in the groups)**	**BLIND** **O) OBJECTIVE** **M) MEASUREMENT** **-were outcome assessors blind?** **-Were outcomes measured objectively?**	**Analysis** **-sufficient power** **-reported effect estimates**
Kebaili et al. (2014)	-Yes, stratified and proportional sampling	-Not randomly allocated	Yes, maintained in the same group, 6% drop out	-blinding not mentioned -Yes, validated questionnaire and Outcomes measured objectively	- power not reported -only P-value reported
Zammit et al. (2016)	-Yes, randomly selected from eligible participants	-Not randomly allocated	Yes, dropout not mentioned	-questionnaire used, blinding not mentioned Yes, standard, validated questionnaire	Yes sufficient power -reported effect estimates
Jihene Maatoug et al. (2015b)	- Yes, randomly selected from eligible participants	-Not randomly allocated	Yes, control and intervention group from different schools. No dropouts	-questionnaire used, trained interviewers but blinding not mentioned Yes, Outcomes measured objectively	Yes, sufficient power -reported effect estimates
Ghammam et al. (2017)	- randomly selected from eligible participants	- Not randomly allocated	No, possible that the control group was contaminated by the intervention effect, dropouts not clear	-questionnaire used, trained interviewers but blinding not mentioned Yes, Outcomes measured objectively	Yes, sufficient power -reported effect estimates
Harrabi et al.	-Yes, stratified and proportional	- Not randomly allocated	Yes, maintained in the same	-blinding not mentioned	Yes,

(2010)	sampling		group, 6% drop out	-Yes, validated questionnaire	sufficient power -reported effect estimates
J. M. Maatoug et al. (2013)	Yes, multiple classes were selected stratified and proportional sampling	- Not randomly allocated	Yes, maintained in the same group, 6% drop out	-blinding not mentioned -Yes, validated questionnaire	Yes, sufficient power -reported effect estimates
Awad Elkarim Elfaki et al. (2020)	Yes, schools were randomly chosen only 79.2% response rate	- Not randomly allocated	Not mentioned	-blinding not mentioned -Yes, objectively measured	Yes, appropriate analysis was displayed
Dendana et al. (2017)	Yes, stratified proportional sampling	-Not randomly allocated	High, 92.9% response rate post intervention	Objectively measured but no blinding of assessors	Yes, sufficient power -reported effect estimates
Jihen Maatoug et al. (2015a)	No, but only overweight and obese school children	- Not randomly allocated	71% post intervention and 57% follow-up in intervention group and 67% post assessment and 59% follow-up for control group	-blinding not mentioned -BMI and meal recall measured objectively by trained interviewers	Yes, sufficient power -reported effect estimates
Ben Cheikh et al. (2020)	Yes, stratified proportional sampling	- Not randomly allocated	Not mentioned	-blinding Not mentioned Only questionnaire, no objective assessment	Yes, sufficient power -reported effect estimates
Kutbi et al. (2019)	Yes, random sampling of the clusters	Yes,	11% dropout from intervention and 19% from control group	-blinding not mentioned Yes objectively measures	Yes, sufficient power -reported effect estimates
Allafi (2020)	Yes	Yes	No mentioned	-blinding not applicable Objectively measured using Pedometers	Yes, sufficient power -reported effect estimates

Habib-Mourad et al. (2014)	Yes	Yes	3% dropout from intervention and 3% from control group	-blinding not mentioned Yes, Outcomes measured objectively	Yes, sufficient power -reported effect estimates
Habib-Mourad et al. (2020)	Yes	Yes	Nutrition group – 9% dropout Teacher group - 12 % dropout	-blinding not mentioned Yes, Outcomes measured objectively	Yes, sufficient power -reported effect estimates
Ayman Bani Salameh et al. (2017)	Yes	Yes	Yes Dropouts not mentioned	Yes -Blinding not mentioned Yes, Outcomes measured objectively	Yes, sufficient power -reported effect estimates
El Ansari et al. (2010)	Yes	Yes	No dropout after enrolment	-Blinding not mentioned Yes, Outcomes measured objectively	Yes, sufficient power -reported effect estimates

3.3.2 Attrition

Acceptable level of attrition in interventional studies is considered to be up to 20% (55). None of the studies reported high levels of dropout (Dendana et al., 2017; El Ansari et al., 2010; Habib-Mourad et al., 2020; Habib-Mourad et al., 2014; Harrabi et al., 2010; Kebaili et al., 2014; Kutbi et al., 2019; Jihen Maatoug et al., 2015a; Jihene Maatoug et al., 2015b; J. M. Maatoug et al., 2013), although six studies did not discuss attrition (Allafi, 2020; Awad Elkarim Elfaki et al., 2020; Ayman Bani Salameh et al., 2017; Ben Cheikh et al., 2020; Ghammam et al., 2017; Zammit et al., 2016).

3.3.3 Instrument and Outcome Measurement

As discussed, most of the tools used to measure study outcomes included validated questionnaires, pedometers and validated weight measurement which were objectively measured. One study used pedometers to measure the steps taken during exercise (Allafi, 2020). Apart from one study (Ayman Bani Salameh et al., 2017), no concealment or assessor blinding was reported during the measurement of the outcomes. The nature of the interventions such as altering calorie intake, regular physical activity and counselling in most studies made participant blinding difficult to execute. Overall, most studies reported all necessary statistical analysis with only one study (Kebaili et al., 2014) reporting p-values without the mean and standard deviation of the outcome of interest.

4. Discussion

The purpose of this scoping review was to compile evidence regarding the effectiveness of school-based interventions on prevention and/or reduction of obesity among children and adolescents in Arab speaking countries in the last decade. As most of the studies were with adolescents, our findings provide greater evidence on the effect of school-based interventions among adolescents compared to children in the region. A total of 16 studies were included from six countries. The school-based interventions focused on physical activity and/or nutritional changes as well as the changes in knowledge and attitude in regard to physical activity and nutrition. Some of the studies engaged parents and others were implemented by teachers and/or nutritionists.

Obesity in children and adolescents has serious implications and thus it is critically important to implement effective interventions aimed focusing on prevention and/or reduction. Articles included in this review have evaluated the impact of different types of interventions on prevention or reduction of obesity among children and adolescent. These interventions have used behavioural, environmental or multicomponent strategies to prevent and/or reduce childhood and adolescent obesity. While some studies used weight reduction strategies for those who were already obese, others focussed on maintaining the health routine of exercise as well is healthy diet. Although the ultimate principles of weight management in children and adolescents are to reduce energy intake and increase energy expenditure, intervention approaches differ (weight reduction vs weight maintenance). Therefore, intervention frameworks should be suitable for specific age groups, and include strategies for prevention and reduction of overweight and obesity.

Interventions to prevent obesity among school-aged children usually focus on promoting healthy lifestyles such as good nutrition and physical activity (Mulrine, 2013). Based on this scoping review, the implementation of strategies to address behavioural changes resulted in reduction in weight and/or obesity in six (6) studies (Awad Elkarim Elfaki et al., 2020; Ayman Bani Salameh et al., 2017; Dendana et al., 2017; Ghammam et al., 2017; Jihen Maatoug et al., 2015a; Jihene Maatoug et al., 2015b). The characteristics of studies in this review varied from six (6)which involved large sample sizes (Awad Elkarim Elfaki et al., 2020; Ayman Bani Salameh et al., 2017; Dendana et al., 2017; Ghammam et al., 2017; Jihen Maatoug et al., 2015a; Jihene Maatoug et al., 2015b), three (3) with long term follow up of 1-3 years (Dendana et al., 2017; Ghammam et al., 2017; Jihene Maatoug et al., 2015b), five (5) studies which used random participant selection (Awad Elkarim Elfaki et al., 2020; Ayman Bani Salameh et al., 2017; Dendana et al., 2017; Ghammam et al., 2017; Jihene Maatoug et al., 2015b), two (2) with low dropout rate (Dendana et al., 2017; Jihene Maatoug et al., 2015b) and four (4) which used validated questionnaires (Awad Elkarim Elfaki et al., 2020; Dendana et al., 2017; Ghammam et al., 2017; Jihene Maatoug et al., 2015b). However, five (5) studies (Awad Elkarim Elfaki et al. (2020); Dendana et al. (2017); Ghammam et al. (2017); Jihen Maatoug et al. (2015a); Jihene Maatoug et al. (2015b)) did not randomly allocate participants, while non-blinding approach to assessing outcome measures was used in six (6) studies (Awad Elkarim Elfaki et al., 2020; Ayman Bani Salameh et al., 2017; Dendana et al., 2017; Ghammam et al., 2017; Jihen Maatoug et al., 2015a; Jihene Maatoug et al., 2015b). In addition, Elfaki and colleagues selected only female participants in a quasi-experimental study (Awad Elkarim Elfaki et al., 2020).

Conversely, a combination of behavioural changes and physical activity did not show significant effect on reduction of obesity or BMI in four (4) studies (Habib-Mourad et al., 2014; Harrabi et al., 2010; Kutbi et al., 2019;

Zammit et al., 2016). However, despite non-significant effect on obesity or BMI strengths and limitations are worthy of discussion. Strengths include large sample sizes (Habib-Mourad et al., 2014; Harrabi et al., 2010; Kutbi et al., 2019; Zammit et al., 2016), long term follow up of 1–3 years (Zammit et al., 2016), random participant selection (Habib-Mourad et al., 2014; Harrabi et al., 2010; Zammit et al., 2016), random allocation of participants (Habib-Mourad et al., 2014; Kutbi et al., 2019), and use of validated questionnaires (Harrabi et al., 2010; Zammit et al., 2016). High dropout rate was observed (Kutbi et al., 2019) or dropout rate was not mentioned in these studies (Harrabi et al., 2010; Zammit et al., 2016). For two studies intervention duration was less than 1 year (Habib-Mourad et al., 2014; Kutbi et al., 2019). Non-random allocation of participants (Harrabi et al., 2010; Zammit et al., 2016) and non-blinding approach of outcome measures (Harrabi et al., 2010; Kutbi et al., 2019; Zammit et al., 2016) was observed.

Our scoping review demonstrated that intervention type is important for changes in outcome variables to occur (Awad Elkarim Elfaki et al., 2020; Ayman Bani Salameh et al., 2017; Dendana et al., 2017; Ghammam et al., 2017; Jihen Maatoug et al., 2015a; Jihene Maatoug et al., 2015b). In this regard, interventions with more than one component were associated with significant changes in outcome variables related to knowledge, attitude and behavioural changes (Awad Elkarim Elfaki et al., 2020; Ayman Bani Salameh et al., 2017; Dendana et al., 2017; Ghammam et al., 2017; Jihen Maatoug et al., 2015a; Jihene Maatoug et al., 2015b). Habib-Mourad et al. (2020) demonstrated a statistically significant improvement in both knowledge and self-efficacy among intervention versus the control groups. This intervention focused mainly on dietary behaviours, as well as physical activity and was delivered via a randomized trial by experts in nutrition in one arm and non-nutrition specialists (trained schoolteachers) on the other. The intervention involved parents as role models. When the programme was delivered by trained schoolteachers, frequency of breakfast intake was increased, crisps consumption was reduced, but no change in fruit and vegetable consumption was observed, however the latter increased when delivered by nutrition experts (Habib-Mourad et al., 2020). Habib-Mourad and colleagues did not report statistically significant improvement in physical activity between the arms of the study. Several studies which evaluated multicomponent interventions have reported similar results to that demonstrated by Habib-Mourad et al. (2020). (Awad Elkarim Elfaki et al., 2020; Ayman Bani Salameh et al., 2017; Dendana et al., 2017; Ghammam et al., 2017; Jihen Maatoug et al., 2015a; Jihene Maatoug et al., 2015b). However, there are mixed results with regards to the impact of multicomponent intervention on outcome variables related to reduction in body weight or obesity.

In relation to the intervention duration, the present review showed that time is an essential variable for changes to occur. Interventions with a duration of less than 1 year (Habib-Mourad et al., 2014; Kutbi et al., 2019) mostly did not show significant impact on body weight than those whose duration ranged from 1-3 years (Dendana et al., 2017; Ghammam et al., 2017; Jihene Maatoug et al., 2015b). However, one 3-year intervention failed to show significant impact on most of the variables related to obesity (Zammit et al., 2016). According to Zammit et al. (2016) there was a lack of sustainability of the intervention which may be associated with a lack of infrastructure/environmental interventions in the program. Indeed, interventions focusing mainly on education may not be effective long-term as a supportive and enabling environment is essential (Zammit et al., 2016). It is recommended comprehensive, targeted programs including a combination of strategies/interventions including changes in infrastructure such as adapted environment to practice physical activity, increased affordability of healthy foods and decreased access to unhealthy foods which complement behavioural educational programs be implemented.

Interventions appear to improve behavioural and outcomes related to physical activity in the short to medium term (3 months – 1 year) however the impact either diminishes or stagnates when interventions lasted more than 1 year. Since studies evaluated school-based health promotion programs, it is plausible the teachers' difficulty to motivate, capture the students' attention, and maintain it overtime could explain this observation. Duration of intervention is an important consideration as short-term strategies have previously demonstrated to be ineffective in treating obesity compared long-term strategies (Gonzalez-Suarez, Worley, Grimmer-Somers, & Dones, 2009; Kothandan, 2014). This may in part explain the non-significant effect of behavioural changes or physical activity interventions on obesity or BMI seen in a number of studies. While an interventions of excessively short period may not produce effects, and an excessively long-term interventions may diminish or stagnate effect due to decrease in levels of motivation over time.

Influences of obesity are multifactorial and the result of complex interconnections among genes, environmental, behavioural (nutrition and physical activity), cultural, social and economic factors (Fishbein, 2001). Literature has revealed that school-based health interventions effective in changing long term health outcomes (Stewart-Brown, 2006). Therefore, a multi-faceted school-based intervention is one of the key solutions to prevent and control the overweight and obesity among children and adolescents. The present scoping review has demonstrated significant and non-significant effects of behavioural interventions on weight reduction and/or obesity which are consistent

with previous a number of systematic reviews (Brown & Summerbell, 2009; Liu et al., 2019; Verjans-Janssen, van de Kolk, Van Kann, Kremers, & Gerards, 2018). Furthermore, while this may not always be applicable, we observed that studies with longer period of follow up showed significant reduction in weight/obesity while studies with shorter term follow up did show significant effect of interventions. Considering the numerous factors, it is not surprising that the treatment of childhood and adolescent obesity is often challenging for public health (Lob-Corzilius, 2007).

5. Limitation

This scoping review has several limitations, some pertain to the findings and some to the conduct of the review. Half of the included studies used quasi-experimental research design which may impact rigour of the studies (Maciejewski, 2020). Based on the quality appraisal result, the overall quality of the included primary studies was moderate, however some, particularly the RCTs, lacked clarity on potential adverse outcomes, appropriate blinding of participants and/or study evaluators, reliable compliance reporting, priori sample size calculations thus power, and maintenance of participants with in the same group throughout the intervention. Other limitations were related to practical issues of completing this scoping review. Study selection was based on eligibility criteria which limited the articles selected that met the criteria of Arabic speaking countries. It is evident that there is a degree of variability occurring in the methodological and theoretical foundation among school-based programs in this review, and this makes evaluating the effectiveness of outcomes more complex and the variability may confound the intervention results (Zenzen & Kridli, 2009).

6. Conclusion

This review has revealed a mixed effect of behavioural interventions on obesity and/or weight. Certain strengths and limitation of studies have influenced the study outcomes. It is necessary to conduct a long-term school-based intervention with rigour methodological and theoretical frameworks as schools can be an avenue or usually seen as a prime site for interventions tackling childhood and adolescent obesity in Arab speaking countries as well as the global context. Tailoring interventions to participants and integrating family and wider environment can give guidance for practitioners and policymakers on how to promote healthy weight in children and address the issue of obesity.

7. Recommendations

This study has several recommendations. Following recommendations for future studies on reduction of weight and obesity:

1) Behavioural interventions, including physical activity programs, are effective in reduction of obesity and weight in school children long term.
2) Strong methodologies are encouraged to plan these interventions such as large sample sizes, low dropout rate, random selection and allocation of participants to interventions and blinding approach of outcome measures.
3) Long term and short-term effect of behavioural interventions on weight/obesity reduction should be investigated further.
4) Use of multicomponent interventions with medium term follow up may prevent or reduce obesity among children and adolescents.

Competing Interests Statement

The authors declare that there are no competing or potential conflicts of interest.

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