A Systematic Review of the Impact of Multi-Strategy Nutrition Education Programs on Health and Nutrition of Adolescents

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ABSTRACT

Objective: To update evidence on the impact of multi-strategy nutrition education interventions on adolescents' health and nutrition outcomes and behaviors.

Design: Systematic review of randomized controlled studies of multi-strategy interventions encompassing nutrition education published from 2000 to 2014 guided by the Preferred Reported Items for Systematic Reviews and Meta-analyses statement.

Setting: Secondary schools in developed countries.

Participants: Adolescents aged 10–18 years.

Main Outcome Measures: Anthropometric and dietary intake.

Analysis: Systematic search of 7,009 unduplicated articles and review of 11 studies (13 articles) meeting inclusion criteria using qualitative comparison.

Results: Four studies reported significant changes in anthropometric measures and 9 showed significant changes in dietary intake. Type of nutrition education varied. Components of the interventions that showed statistically significant changes in anthropometric and dietary intake included facilitation of the programs by school staff and teachers, parental involvement, and using theoretical models to guide the intervention's development. Changes in canteens, food supply, and vending machines were associated with significant changes in dietary intake.

Conclusions and Implications: Multi-strategy interventions can have significant impacts on nutrition of adolescents when the nutrition education is theoretically based and facilitated by school staff in conjunction with parents and families, and includes changes to the school food environment.

Key Words: adolescents, dietary intake, nutrition education, school, healthy eating, overweight, fruit, vegetable, sugar-sweetened beverage (*J Nutr Educ Behav*. 2016;48:631-646.)

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INTRODUCTION

Adolescence is a critical period of development when optimal nutrition to maximize growth and establish healthy eating habits is crucial for transition into adulthood.[1] As the social environment for adolescents diversifies and they become more independent, the key influences on their eating practices begin to change. Social norms, friends, and peers as well as the accessibility of food start to have a greater influence on their nutrition-related behaviors.[2]

Previous evidence-based reviews identified key components that contribute to the effectiveness of nutrition education interventions for school-aged children.[3-8] The most effective components were found to have a behavioral focus and use theory-based instructional strategies, adequate dose, peer involvement, self-assessment and feedback, and environmental interventions that complemented the behavioral lessons and community involvements. The findings of these reviews were consistent with the growing body of evidence related to whole-school approaches. The evidence recognized the importance of extending beyond just the classroom curriculum to include the school community, its members, and the environment to affect students' health and well-being outcomes.[9,10] The use of multiple strategies and activities was inherent in this approach. Much of this evidence existed only for younger children.

In 2002, Hoelscher et al[5] reviewed nutrition interventions aimed specifically at adolescents. The reviewers identified 14 population-based studies conducted in schools, clinics, or

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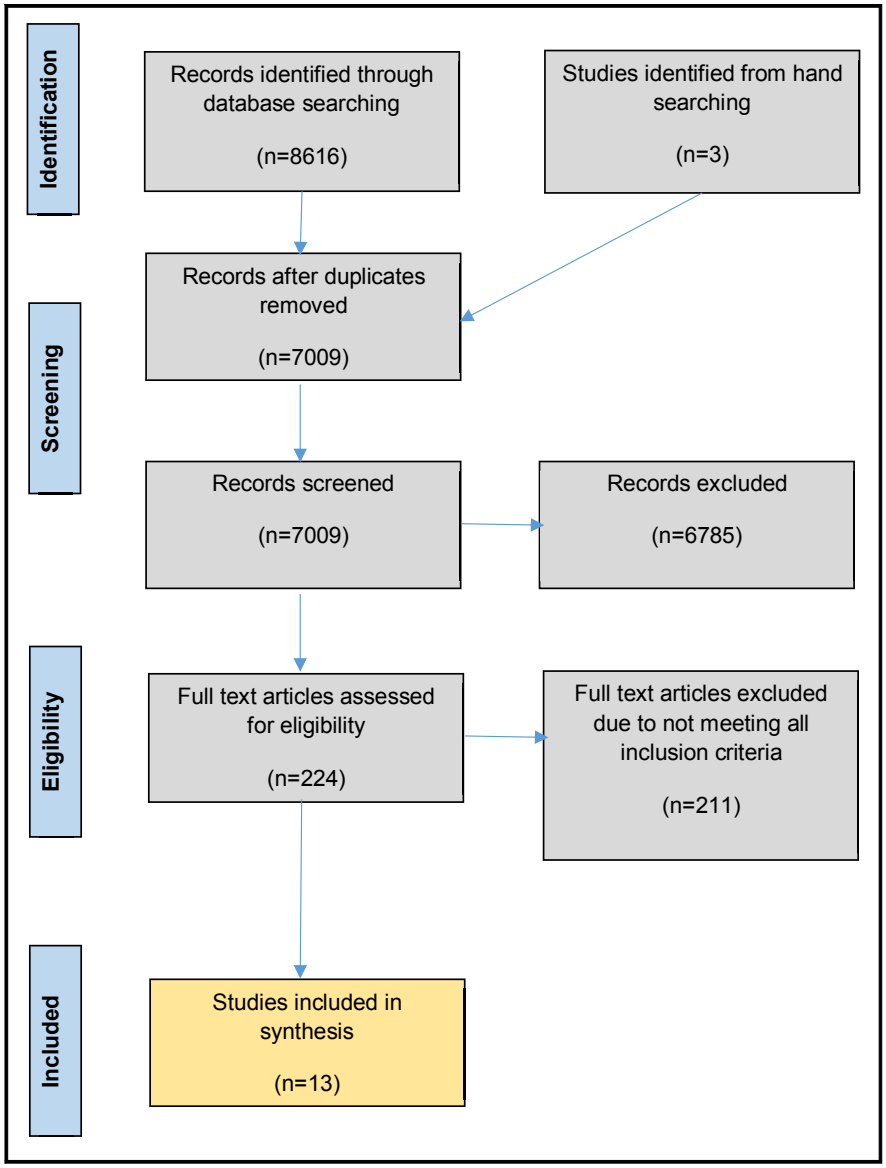

Figure. Flowchart depicting selection process undertaken according to preferred reporting items for systematic reviews and meta-analyses.

communities published between 1994 and 2000 targeted at adolescent populations aged 11–18 years. Intervention components previously identified were echoed in that review; the more successful studies included multiple strategies such as having a behavioral focus, as opposed to a knowledge-based focus, using theory-based instructional strategies, focusing on individual and environmental behaviors related to diet and physical activity, and using appropriate dose (duration and intensity) and educational strategies.[1,3] This was in line with a review of reviews conducted by Roseman et al[7] related to school-based nutrition interventions, 2 of which included only adolescent populations.[5,11] Hoelscher et al suggested that intervention components such as coordination for nutrition and physical education interventions, policy changes, use of technology such as CD-ROMs, and dissemination of effective programs would be future trends in developing effective nutrition interventions for adolescents.[5]

These reviews need updating to reflect increasingly complex challenges in the environments to which adolescents are exposed across the world. The aim of this systematic review was to update and build upon the review by Hoelscher et al[5] by exploring the impact of multi-strategy interventions that encompass nutrition education on adolescents' health and nutrition outcomes and behaviors.

METHODS

Literature Search

No institutional review approval was required for this study as humans were not involved. The first author conducted a search in September, 2014 using the following key terms: "nutrition education interventions," "adolescents," and "developing" countries. The databases CINAHL Plus, EMBASE, ERIC, OVID Medline, PsycINFO, and Web of Science were searched with limits to studies published in English and conducted in humans. An example of the search term strategy is provided in the Supplementary Material.

Inclusion and Exclusion Criteria

Criteria for inclusion in the review were: (1) randomized control studies published from 2000 to 2014 designed to evaluate multi-strategy interventions that encompassed nut rition education, (2) studies investigating adolescent populations in developed countries, and (3) studies that reported on relevant health and nutrition-related outcome or behavioral measures. For the purposes of the review, adolescents were defined according to the World Health Organization definition of people aged 10–19 years and developed countries were identified using the World Bank's definition.[12]

Outcome measures included changes in at least 1 of the following: anthropometric measures (weight, body mass index [BMI], BMI z score, skinfolds, waist circumference, or percent body fat), biochemical markers, or dietary consumption data (using tools such as a food frequency questionnaire, 24-hour dietary recall, or 3-day food record). Changes in dietary consumption data recorded included changes in dietary intake of fruits and vegetables, snack foods, fat (total, saturated, polyunsaturated, and monounsaturated), sucrose, sugar-sweetened beverages, and soft drinks. Multi-strategy interventions were identified as interventions in which nutrition education was delivered in conjunction

with complementary strategies designed to reinforce key nutrition messages such as parental involvement, school fruit and vegetable programs, establishing nutrition policies, and developing working groups.

Studies that reported on nutrition outcome and behavior measures related to changes in attitudes, body image, knowledge, self-confidence, self-esteem, and skills only were excluded. Studies were also excluded if they were treatment programs or were designed for specific adolescent subgroups (eg, overweight teenagers) because the authors were interested in preventive approaches.

Selection Process

All search results retrieved were exported into an EndNote X7.1 Library (Thomson Reuters, Toronto, Canada, 2014) for eligibility screening. The review followed the Preferred Reporting Items for Systematic Reviews and Meta-analyses systematic review process.[13] The first author initially screened all titles and abstracts independently to identify and remove duplicates. In addition, the first author screened and coded all remaining titles and abstracts according to the inclusion criteria. Ineligible articles were removed and their reason for exclusion (not a study or randomized control study; not the correct population of adolescents aged 10–19 years living in developed countries; not a multi-strategy nutrition education intervention in schools; or not the correct outcome measures) was noted. The coauthors independently screened a 10% sample of the remaining titles and abstracts. Any discrepancies were resolved among the 3 reviewers via discussion to ensure consistency (Figure). In addition, citation searching was undertaken on reference lists of articles that were included in the review after titles and abstracts were screened.

Data Extraction and Analysis

Full copies of all studies included for further review were retrieved and assessed according to the selection criteria by the first author. When only abstracts were available, the corresponding authors were contacted for full data. Two authors independently conducted systematic data extraction for all included studies. All data extraction was cross-checked and differences were discussed until consensus was reached by all authors. When available, extracted data included author name, journal, year of publication, study aims and location, participant and study characteristics, nutrition education inter vention characteristics, outcome measures, and key findings (Table 1).

Because of the diversity of outcome measures, meta-analyses of the results were not attempted. The data synthesis was based on content analysis, "an observational research method that is used to systematically evaluate the symbolic content of all forms of recorded communications."[14] Studies reporting at least 1 statistically significant result were identified and included in the content analysis. Tables 2 and 3 list intervention characteristics that were consistent with those previously identified as essential to the provision of effective nutrition education for adolescents. The frequency of intervention characteristics was calculated and analyzed according to whether anthropometric or dietary intake changes were observed. Outcomes were included in the content analysis only if they reported a statistically significant value ($P < .05$ unless otherwise specified by the study) or stated that the results were statistically significant.[14] For example, all 3 studies that showed statistically significant impacts on BMI or BMI z score involved parents and the nutrition education was facilitated by school teachers or staff (Tables 2 and 3).

Quality Assessment

Two authors conducted quality assessment of all included studies independently using a validated quality criteria checklist for primary research.[15] The checklist followed a yes–no question structure; it included 4 relevance questions to address applicability to practice and 10 validity questions to address scientific soundness. Any variations were discussed and resolved by consensus between the authors. Through the use of the checklist each study was classified as positive (≥6 yes), neutral (4–5 yes), or negative (0–4 yes) (Table 1) as per instructions. Studies with a positive or neutral rating were included in the synthesis.

RESULTS

A total of 8,616 articles were retrieved by the database search and 3 from the hand search (Figure); 224 articles were retrieved for full text review. The researchers excluded 6,785 articles because they: (1) were not a study or randomized control study (n = 2,548); (2) were not conducted in adolescent populations in developed countries (n = 2,833); (3) were not a multi-strategy nutrition education intervention (n = 1,350); or (4) did not report on anthropometric, biochemical, or dietary intake measures (n = 54). Thirteen articles met the selection criteria. The most frequent reasons articles were excluded in the second pass were that: (1) the study was not conducted in a developed country or focused on primary school children aged <10 years (n = 89), (2) the study was not of randomized control design (n = 43), (3) the study intervention did not include a school-based multi-strategy nutrition education intervention (n = 64), and (4) the study did not report on anthropometric or dietary intake outcome measures (n = 15).

The 13 articles reported on 11 different studies (Table 1).[16-28] Participant numbers ranged from 191[25] to 3,503[17] and included adolescents aged 10[28] to 18 years.[26] All multi-strategy approaches involved the school environment.

The majority of studies were conducted in European countries including Belgium (n = 1),[21,22] Greece (n = 1),[25] Finland (n = 1),[23] Norway (n = 2),[16,18] and Sweden (n = 1).[27] One study was conducted across Norway, Spain, and The Netherlands.[28] The remaining 4 studies were conducted in the US (n = 2)[17,24] and Australia (n = 2).[19,27] Of the 11 studies, 9 were rated as positive[17,19-28] and 2 were neutral.[16,18] Statistically significant results were reported in 10 of the included studies according to the results of the content analysis (Tables 2 and 3).[17-28]

Table 1. Studies Included in Systematic Literature Review

Author, Year	Theoretical Basis; Quality	Participant Characteristics (Sample Size), Country	Intervention Characteristics	Outcome Measures; Follow-Up	Results
Bere et al, 2005[16]	SCT; neutral	Sixth graders (n = 369), Norway	Classroom component: 7 sessions (3 45-min lessons) over 7 mo were facilitated by home economics teachers. Teachers were encouraged to include topics including recommended dietary intake and health benefits of eating FV into the regular curriculum. Small-group activities included taste testing, food preparation, and general information about FV use and availability. Parental component: Meetings were held to inform parents about the project. Six themed newsletters were distributed (berries; vegetables; fruits; potatoes; salads; and fruits, berries, and vegetables) that included health-related information, recipes, and activities for parents to do with their children. School fruit program: National FV subscription program in Norway. Parents paid about €0.30/d/child for a piece of fruit or a carrot each school day at participating schools.	Changes to FV intake; upon completion and 1 y after intervention	No statistically significant effect of intervention was observed on FV intake upon program completion or 1 y after intervention
Birnbaum et al, 2002[17]	SCT; positive	Seventh graders (n = 3,503), US	Students were allocated to 1 of 4 exposure groups: (1) control (lowest exposure), (2) school environment intervention only, (3) classroom curriculum plus school environment intervention, or (4) peer leaders plus classroom curriculum plus school environment intervention (highest exposure). Classroom curriculum intervention: 10 nutrition education lessons facilitated by regular classroom teacher with assistance of trained peer leaders, on self-monitoring, goal setting, hands-on snack preparation, skills for choosing healthy foods, and overcoming barriers to making healthful choices. 3 Parent Packs were distributed that included newsletters with lead articles on how parents could help their children	Changes to FV and fat intake; immediately after intervention	Significant increase in FV intake at follow-up in peer leaders group compared with classroom curriculum plus school environment group ($P = .01$) No significant changes in control group or school environment intervention–only group Significant increase in food choice scores (indicative of making lower-fat choices) in peer leaders plus classroom room curriculum plus school environment exposure group ($P = .002$) and classroom

			eat more FV and reduce fat, behavioral tips, and quizzes. Families received a $10 gift certificate if they completed 10 behavioral activities such as Serve a fruit or vegetable with dinner tonight. School environment intervention: 6 of the 8 intervention schools developed a school nutrition advisory council consisting of school staff, parents, and students to develop policies to limit sweets and nonnutritious foods as rewards for students and increase availability of fruits, vegetables, and lower-fat foods at school events. Activities included increased availability and taste testing of healthy options, displaying posters and table tents in the lunchroom, and vending machines comparing fat and sugar in snack choices. Peer leaders intervention: Students were elected by their peers and assisted teachers to deliver classroom interventions by leading small-group activities and discussions. Students received full-day training giving hands-on practice in leading intervention activities and problem-solving activities in small groups.		curriculum plus school environment group ($P < .001$) No significant changes in food choice scores for control group ($P = .49$) or school environment intervention–only group ($P = .06$)
Bjelland et al, 2011[18]	Not stated; neutral	Sixth graders (n = 1,465), Norway	5 monthly lessons were covering 5 topics: diet and physical activity, meals, 5-A-Day, sugar-rich beverages, your choice. Children brought FV from home for weekly FV breaks in class. Physical activity breaks were conducted in classrooms and sports equipment was provided at recess. Active transport was also encouraged by physical education teachers. Posters were displayed and parent fact sheets/brochures were distributed targeting behaviors and topics such as Cutting fruit and vegetables and Meals—a value worth fighting for.	Changes to SSB intake; mid-interventions at 8 mo	Significantly less SSB consumed on weekends by IG girls than CG girls ($P = .004$) No significant effects observed in boys
Dewar et al, 2013[19]	SCT; positive	Female eighth graders (n = 237), Australia	Teachers facilitated the program with the assistance of the research team. Participants were sent text messages weekly throughout the second and third terms and biweekly throughout the fourth term to reinforce targeted behaviors.	Changes in BMI and % body fat; 12 mo after intervention	No significant change observed at 24 mo in BMI in CG or IG (*P* not reported) Significant group × time interaction for percent body fat in favor of IG after 24 mo ($P = .006$)

(continued)

Table 1. Continued

Author, Year	Theoretical Basis; Quality	Participant Characteristics (Sample Size), Country	Intervention Characteristics	Outcome Measures; Follow-Up	Results
			Nutrition education intervention: 3 practical nutrition workshops were facilitated by accredited practicing dietitians on the benefits of healthy eating as well as key behavioral messages to assist students in becoming confident in selecting, preparing, and consuming healthy low-cost food. Physical activity intervention: Enhanced school sport sessions included a 10- to 15-min education session facilitated by teachers and lunchtime sessions. Pedometers and handbooks were provided to all students for self-monitoring. Parent involvement: 4 newsletters were distributed throughout the study period.		
Foster et al, 2008[20]	Not stated; positive	Fourth through sixth graders (n = 844), US	School self-assessment: Schools completed the Centers for Disease Control and Prevention School Health Index and formed advisory groups including administrators, teachers, nurses, coaches, and parents. Advisory groups developed action plans. Staff training: Staff offered 10 h of nutrition education training per year and received curricula and supporting materials with theme packets designed to integrate classroom lessons with cafeteria promotions and parent interventions. Nutrition education: Schools aimed to provide 50 h of food and nutrition education per student per school year and integrated education across classroom subjects to show how food choices and physical activity are tied to personal behavior, individual health, and the environment. Nutrition policy: All soda, chips, and other drinks and snacks sold in vending machines and à la carte in the cafeteria were removed and	Changes in BMI and changes in energy, fat, and FV intake; end of first and second year of program	Significantly fewer children in IS (7.5%) than in CS (14.9%) became overweight after 2 y ($P < .001$) After controlling for gender, age, and race/ethnicity, the predicted odds of incidence of overweight were approximately 33% lower for the IG ($P < .05$) At 2 y: odds of overweight and obesity were approximately 15% lower for the IG ($P < .05$) After controlling for gender, age, race/ethnicity, and baseline prevalence, the predicted odds of overweight prevalence were 35% lower in the IG ($P \leq .001$). No differences between IS and CS in prevalence of obesity No significant difference between IS (10.7%) and CS (7.6%) with

			replaced with items that met the Dietary Guidelines for Americans. Social marketing: Raffle tickets were offered to students who purchased healthy snacks and beverages or brought in snack items from home that met nutritional standards. Prizes included bicycles, indoor basketball hoops, jump ropes, and calculators. Easily recognizable characters were paired with sayings or slogans designed by students to reinforce messages. Parent/family involvement: Parents were invited to school association meetings, report card nights, parent education meetings, and weekly nutrition workshops. Unhealthy parent fundraisers were discouraged. Parents were encouraged to assist their children with the 2-1-5 challenge (to participate in $<$ 2 h/d of sedentary activity, participate in $>$ 1 h/d of physical activity, and eat $>$ 5 servings/d of FV).		respect to the remission of overweight ($P = .40$) or rates of obesity ($P = .50$). Odds of remission of overweight or obesity were significantly higher for the IG ($P < .01$) There were no significant differences in dietary intake
Haerens et al, 2006[21]	TPB; positive	Seventh and eighth graders (n = 2,287), Belgium	School staff facilitated the intervention under the guidance of research staff. Working group: Composed of the principal, physical education teacher, and other teachers to oversee implementation. Nutrition intervention: Focused on 3 behavioral changes: (1) increase fruit consumption to at least 2 pieces per day, (2) reduce soft drink consumption and increase water consumption to 1.5 L/d, and (3) reduce fat intake. Schools were asked to sell fruit at school at very low prices or for free at least once per week and provided free water from drinking fountains or at lower prices than soft drinks. Children received information through folders and posters about health benefits of consuming fruit and water instead of snack items and soft drinks. Children used a computer-tailored intervention to learn about fat and fruit intake. Teachers were encouraged to organize healthy breakfasts and educational games in addition to developing extra activities to support the intervention. Parent involvement: Parents attended interactive meetings on healthy food, physical activity, and	Changes in fat, fruit, water, and soft drink intake; end of second year of program	No significant intervention effects on eating behaviors were found as a result of the second intervention year No significant differences in fat intake in girls were observed between the IG with parental support and the intervention-alone group ($P = .60$) as a result of the second intervention year No significant 2-y post-baseline intervention effects on eating behaviors in boys were found Significantly higher decreases in IG girls' fat (20 vs 10 g; $P < .05$) and percent energy from fat compared with CG girls (9% vs 5%; $P < .001$) were observed 2 y after baseline

(continued)

Table 1. Continued

Author, Year	Theoretical Basis; Quality	Participant Characteristics (Sample Size), Country	Intervention Characteristics	Outcome Measures; Follow-Up	Results
			the relationship with overweight and health. Information was distributed in school papers and newsletters 3 times per year. Parents received a free CD with the adult computer-tailored intervention on fat intake. Physical activity intervention: Schools were encouraged to create more varied opportunities for physical activity during breaks, at noon, and after school. Schools were provided with extra sports materials (ropes, balls, and beach ball sets) and encouraged to encourage active transport. Students completed a personal computer-tailored intervention to measure physical activity levels once per year.		
Haerens et al, 2007[22]	TPB; positive	Seventh and eighth graders (n = 2,840), Belgium	Intervention replicates study of Haerens et al (2006)	Changes in fat, fruit, water, and soft drink intake; end of first year of program	No significant increases in self-reported fruit intake and water consumption or positive effects on soft drink consumption (*P* not reported) Significant decrease in fat intake and percent energy from fat in girls of the IG with parental support compared with the IG alone ($P < .005$) or CG ($P < .001$)
Hoppu et al, 2010[23]	SCT; positive	Eighth graders (n = 659), Finland	Food environment: Target groups were headmasters, teachers, and school catering personnel. Drama workshops covered topics of eating and school meals. Discussions and information sessions were held with school personnel to discuss how they could improve school food environments. Parents received a magazine covering healthy eating topics and attended meetings where a school meal and information on the school intervention were provided. Vending machines containing sweets and soft	Changes in sucrose, fiber, FV intake; immediately after intervention	Significant increase in rye bread consumption of IS girls compared with the CS girls ($P = .03$) and significant decrease in sweets consumption ($P = .006$) No significant differences between IS and CS boys in rye bread or sweets consumption Daily consumption of vegetables decreased among boys but not

			drinks were removed and fresh bread and snacks for sale in selected schools were improved to include sandwiches, fruit, and milk instead of sweet cakes. Nutritional education: Implemented by teachers during lessons using posters, pictures of typical snacks, informative brochures, games, and tests covering topics such as sugar, FV, and fiber. Teachers were offered ready-planned lessons and were encouraged to use these materials during their normal lessons.		girls in both the IS and CS (results not significant) Fruit consumption remained stable in IS boys and decreased among CS boys (results not significant) Significant decrease in sweet consumption in IS girls compared with CS girls ($P = .03$) Sugary soft drink consumption remained constant among IS boys but increased significantly in CG boys ($P = .02$) No differences in consumption of bread and fruit as snacks between CS and IS IS consumption of fruits remained constant (when energy-adjusted) whereas consumption decreased significantly in CS ($P = .04$) Sucrose intake in IS fell significantly from 12.8% to 10.5% of total energy intake ($P = .01$) Folate intake increased significantly in IS ($P = .04$)
Lytle et al, 2004[24]	SCT; positive	Seventh and eighth graders (n = 2,883), US	Intervention replicates study of Birnbaum et al. (2002)	Changes to FV and fat intake; 1 y after intervention completion	IS students had slightly higher food choice scores indicative of making lower-fat choices (6.15 vs 5.78; confidence interval [CI], 0.038–0.713) Significantly higher food choice scores were found among high-dose students (6.38), low-dose students (5.84; CI, 0.16–0.93), and control students (5.89; CI, 0.19–0.80). No significant changes in FV intake were observed in CS or IS
Mihas et al, 2009[25]	SCT; positive	12- and 13-y-olds (n = 191), Greece	Classroom component: Facilitated by home economics teachers supervised by a health visitor or family doctor. 12 h of classroom material in 12 wk adapted from American Health	Changes in dietary intake and BMI; 15 d and 12 mo after intervention	Short-term (15-d) effects: Significant decrease in daily energy intake ($P < .001$), red meat consumption ($P = .03$),

(continued)

Table 1. Continued

Author, Year	Theoretical Basis; Quality	Participant Characteristics (Sample Size), Country	Intervention Characteristics	Outcome Measures; Follow-Up	Results
			Foundation *Know Your Body* program and health promotion activities and materials developed by the Greek Ministry of Education and the National Foundation for the Youth. Classroom modules aimed to develop behavioral capability, expectations, and self-efficacy for healthy eating and foods selection. Teachers participated in 2 3-h seminars to familiarize them with the objectives of the program and their roles and increase awareness of the significance of incorporating health and nutrition into curriculum. Parental component: Parents of IG participants attended 2 meetings and received files containing their child's baseline results and information related to the dietary habits of children to prevent the development of chronic diseases. Parents of CG participants received an envelope (via postal mail) with all medical screening results for their child in addition to some brief comments. CG parents did not receive health education and no parental educational sessions took place.		total fat ($P < .001$), and saturated fat ($P < .001$) in the IG Significant increase in daily consumption of protein in the IG ($P < .001$) No significant differences in the CG in energy intake or nutrient components Significant increases in weekly consumption of poultry ($P = .04$), ready-to-eat breakfast cereals ($P = .005$), and fruit ($P = .04$) in the IG No significant difference in consumption frequencies observed in the CG No significant changes in BMI in IG (23.9 vs 24.0; $P = 0.50$) or CG (24.5 vs 24.3; $P = 0.23$) Long-term (12-mo) effects: Significant decrease in daily energy intake compared with baseline in IG ($P = .05$) Significantly lower total fat ($P < .001$) and saturated fat ($P < .001$) intake and higher protein intake ($P < .001$) than at baseline in IG Significant increase in daily monounsaturated fat intake in the CG ($P = .002$). No other significant differences in energy or nutrient intake Significant increase in poultry ($P = .03$), ready-to-eat breakfast cereals ($P = .001$),

					and fruit ($P = .05$) consumed weekly than at baseline in IG Significant decrease in weekly consumption of red meat ($P = .02$) and non-homemade meals in IG ($P = .02$) No significant differences were found in the frequency of consumption of any food categories for the CG Mean BMI decreased significantly in the IG from baseline (23.3 vs 24.0; $P < .001$) but not in the CG (24.8 vs 24.3; $P = .36$)
Millar et al, 2011[26]	Community-based capacity building approach; positive	12- to 18-y-olds (n = 2,054), Australia	Education implemented by school project officers within multisite community intervention with 10 overall objectives. Objectives and key strategies related to nutrition education: to decrease the consumption of high-sugar drinks significantly and to promote the consumption of water through school canteen and vending machine policies, curriculum activities, and parent information; to increase the proportion of young people eating breakfast significantly through parent information and promotion of time management skills for young people; to increase FV consumption significantly through canteen availability and pricing of FV, programs and activities, and parent information about FV; and to increase the healthiness of school food significantly through school food policies and canteen availability, promotion, and pricing. Programs and activities included breakfast programs, one-off healthy eating days, sweet drinks displays, and a parent evening with a leading nutritionist. Infrastructure and equipment changes included installation of new water foundations, construction of vegetable gardens, reduction or removal of vending machines, as well as the introduction of whole-school food and water policies.	Changes in dietary intake and BMI; 12 mo after intervention	IG gained significantly less weight (740 g; $P = .04$) and less BMI z score (0.08 units; $P = .03$) than did students in the CG (when clustered by school) No significant differences or improvements in breakfast consumption, home lunches, or FV consumption; or limiting soft drinks, cordials or snack foods, observed for intervention students over comparison students (results not reported)

(continued)

Table 1. Continued

Author, Year	Theoretical Basis; Quality	Participant Characteristics (Sample Size), Country	Intervention Characteristics	Outcome Measures; Follow-Up	Results
			Physical activity initiatives included school physical activity policies, school walking programs, lunch programs, parent education sessions, and partnering with local sporting clubs.		
Prell et al, 2005[27]	TPB; positive	Eighth graders (n = 228), Sweden	IS eighth graders received more fish in canteen lunches and some received additional home economics classes focused on fish consumption. School lunch component: Intervention focused on the preparation and appearance of fish meals, extending choices and marketing. Canteen personnel were trained to provide additional fish dishes, either smoked mackerel or pickled herring, and improved accompaniment variety. School lunchroom was decorated with fish-related objects. Home economics component: 5 classroom cooking experiences instead of the usual 3 were implemented on topics including: cooking fish dish voted for by the pupils, nutrition and fish, how to fillet fish, and cooking fish.	Changes in fish intake; immediately after intervention	Significantly more SL + HE group tasted and/or ate fish after intervention compared with CG (results not reported) SL + HE group did not differ significantly from SL group Proportion of eaters in the SL + HE group increased from 56% at baseline to 71% at follow-up. In the SL group eaters increased from 59% to 69%. In the CG there was a decrease from 77% to 69% At baseline, for boys, 4% were non-eaters, 20% were tasters, and 76% were eaters. For girls, 4% were non-eaters, 42% were tasters, and 54% were eaters. This difference was significant ($P < .01$)
Te Velde et al, 2008[28]	Not stated; positive	Fifth and sixth graders (n = 1,472), Norway, Spain, and The Netherlands	16 lessons guided by worksheets and a Web-based computer-tailored feedback tool were facilitated by teachers. Parental component: Parents were encouraged to become involved in homework assignments and received newsletters and a modified version of the Web-based computer-tailored tool to provide parents with personalized feedback on their own FV intake. School FV program: In Norway children from both IGs and CGs were invited to participate in a national FV subscription program to receive a	Changes in FV intake; immediately after intervention and 12 mo after intervention	First follow-up: A significant increase in intake was observed for IG consuming 56.8 g/d more FV than the CG ITT analysis showed a significant intervention effect in The Netherlands for total FV intake and total fruit intake alone during school hours and for the combined Norwegian and Spanish sample outside school hours (results not shown)

	piece of fruit or a carrot during lunch or fruit break each school day. Parents paid a fee for this program. In The Netherlands all IS participants received a piece of fruit, a carrot, or a tomato for free 2 d/wk. In Spain IS participants received fruit for free during the first 2 mo of the intervention. Optional component: In The Netherlands and Norway local media were used to raise awareness, and in Spain school health services counseled students during their regular health visits.	Second follow-up: At the second follow-up the intervention effect differed by country. Significant effects were not observed in Spain or The Netherlands In Norway the intervention effect was significantly higher than at the first follow-up for total FV intake ($P = .04$) and total fruit intake alone ($P = .002$) ITT analysis showed a significant intervention effect in The Netherlands for total FV intake and total fruit intake alone at the first follow-up during school hours (results not shown) ITT analysis showed a significant intervention effect on intake at school in Norway only and outside school hours of the combined Norwegian and Spanish sample (results not shown)

BMI indicates body mass index; CG, control group; CS, control school; FV, fruit and vegetable; HE, home economics; IG, intervention group; IS, intervention schools; ITT, intention to treat; SCT, Social Cognitive Theory; SL, school lunch; SSB, sugar-sweetened beverage, TPB, Theory of Planned Behavior.

Characteristics of Nutrition Education Delivered in Included Studies

The nutrition education component of the 10 studies reporting significant results varied. The number and duration of nutrition education sessions varied. This included 3 interactive workshops with dietitians in a study conducted with girls in Australia;[19] 16 lessons in a study focusing on fruit and vegetable consumption across Spain, The Netherlands, and Norway;[28] 12 hours of classroom activities over 12 weeks;[25] and 50 hours/student/school year.[20] Three studies did not stipulate the number of sessions or time dedicated to the provision of nutrition education.[21-23,26]

Nutrition education was delivered by school staff and teachers in 9 of the 10 studies. Accredited dietitians facilitated the interactive workshops conducted in the study with girls in Australia with the assistance of classroom teachers.[19] Home economics teachers were identified as the key facilitators in 3 studies.[16,25,27] Trained student peer leaders were also used in 1 study in which eighth-grade students assisted with seventh-grade lessons.[17,24]

This review identified 3 studies that involved the use of technology. Dewar et al[19] sent text messages to participants throughout the duration of the study. Haerens et al[21,22] used an in-class, computer-tailored intervention to focus on fat and fruit intake, and Te Velde et al[28] incorporated a Web-based, computer-tailored feedback tool for students. Four studies incorporated physical education programs and activities.[18,19,21,22,27] Two of those studies showed statistically significant changes in percent body fat or weight/BMI z scores in participants.[19,26]

Included studies focused on dietary behavior changes related to consumption of fruit and vegetables,[16,17,23,24,28] fruit consumption,[21,22] water consumption,[21,22] fish,[27] fat,[17,21,22,24] sugar-sweetened beverages,[18,21,22] fiber,[23] and sucrose.[23] Two studies investigated overall changes in dietary intake behaviors.[25,26] Several studies investigating changes in anthropometric measures also focused on nondietary behaviors such as engagement in physical activity (those results were not reported).[19,20,25,26]

Table 2. Content Analysis of Interventions Showing Statistically Significant Impacts on Anthropometric Measures

Intervention Strategies	Dewar et al[19]	Foster et al[20]	Mihas et al[25]	Millar et al[26]
Theory-based instructional strategies	X		X	X
Policies developed at school		X		X
Teachers/staff facilitating		X	X	X
Parental involvement	X	X	X	X
Changes in canteen, food supply, or vending machines		X		X
Program built into existing curriculum		X	X	
Use of peer leaders and instructors				
Incorporation of student self-assessments with personalized feedback			X	
Use of innovative multimedia technology tools	X			
Physical activity component	X			X

Significant dietary changes were reported regarding the consumption of fruit,[23,25,28] fruits and vegetables,[17,28] and fat.[17,21,22,24,25] Changes were seen most frequently when parental involvement and facilitation of nutrition education by teachers and staff were present and when changes were made in the school food environment in the canteen, food supply, or vending machines (Table 3).[17,18,21-25,27,28] Parental involvement such as the provision of newsletters, fact sheets, meetings, and shared homework tasks was identified in 6 studies.[17,18,21-25,28] Other components that contributed included theory-based instructional strategies[17,21-25,27] and incorporating changes in the canteen, food supply, or vending machines.[17,21-24,27,28] No trends were noted based on the length of the follow-up period. Nonsignificant dietary changes in sugar-sweetened beverage consumption were reported in a number of studies,[18,21-23] with the exception of 1 study that showed a significant decrease in consumption by girls on weekends.[18] These interventions did not include the development of school-based food policies or the incorporation of student self-assessments with personalized feedback.

Multi-Strategy Factors Contributing to the Success of Interventions Revealed by the Content Analysis

Components of these multi-strategy interventions that appeared most frequently in studies showing statistically significant changes on anthropometric measures were incorporating parental involvement and having teachers (classroom or home economics) or school staff members facilitate nutrition education (Table 2). Other contributing factors included the use of theory-based instructional strategies,[19,25,26] incorporating policy changes within school settings, and including changes in canteens, food supply, and vending machines.[20,26] Combining nutrition education with physical activity programs was also a key contributing factor.[19,26]

Table 3. Content Analysis of Interventions Showing Statistically Significant Impacts on Dietary Intake Measures

Intervention Strategies	Birnbaum et al[17]	Bjelland et al[18]	Haerens et al[21]	Haerens et al[22]	Hoppu et al[23]	Lytle et al[24]	Mihas et al[25]	Prell et al[27]	Te Velde et al[28]
Theory-based instructional strategies	X		X	X	X	X	X	X	
Policies developed at school	X					X			
Teachers/staff facilitating	X	X	X	X	X	X	X	X	X
Parental involvement	X	X	X	X	X	X	X		X
Changes in canteen, food supply, or vending machines	X		X	X	X	X		X	X
Program built into existing curriculum					X		X	X	
Use of peer leaders and instructors	X					X			
Incorporation of student self-assessments with personalized feedback	X					X	X		X
Use of innovative multimedia technology tools			X	X					X
Physical activity component		X	X	X					

Social Cognitive Theory was identified as the basis for 3 of the interventions[17,23-25] and the Theory of Planned Behavior was used by 2 interventions.[21,22,27] Bjelland et al[18] and Te Velde et al[28] did not identify the use of theory-based instructional strategies. Environmental changes in the canteen, food supply, or vending machines were seen in 5 of 7 studies including that of Te Velde et al, in which students were provided with the opportunity to participate in a free fruit and vegetable program (The Netherlands) or a discounted fruit and vegetable program (Spain or Norway).[17,21-24,27,28] Other contributing factors included incorporating the intervention into the existing curriculum,[23,25,27] incorporating student self-assessment with personalized feedback,[17,24,25,28] and using innovative multimedia technology tools such as sending weekly text messages to students and interactive computer-tailored fat intake interventions that provided students with normative feedback on their dietary behaviors and tips and suggestions on how to decrease fat intake (Table 1).[19,21,22]

DISCUSSION

This review builds on and updates the most recent evidence of the impact of multi-strategy nutrition education interventions specifically in school-based adolescent populations in developed countries. It supports the findings of previous reviews in children and adolescents that multi-strategy nutrition interventions can have significant impacts on anthropometric measures and dietary intake and provides evidence to suggest that some strategies may have more of an impact than others specifically when working with adolescent populations.[5-7]

This review found 11 studies that were multi-strategy in design that resulted in a change in anthropometry and/or food-related behaviors. Of the additional program components previously described by Hoelscher et al,[5] 7 identified the use of a theoretical framework such as Social Cognitive Theory or the Theory of Planned Behavior for program design. Duration and intensity of the nutrition education component varied, along with educational strategies.

> Multi-strategy school-based nutrition education interventions can have an impact on anthropometric and dietary intake measures in adolescents.

The review by Hoelscher et al[5] proposed that program components such as the coordination of nutrition and physical education interventions and use of technology such as CD-ROMs would become increasing important and common in nutrition interventions aimed at adolescents. The current review identified 3 studies that included the use of technology,[19,21,22,28] 4 of which had coordinated nutrition and physical education interventions.[18,19,21,22,26] The findings also support the growing body of evidence related to the importance of whole-school approaches, which encompass a variety of strategies implemented within the curriculum and the overall school environment to affect students' health outcomes.[9,10]

A key strength of the current review was the high level of evidence and quality of the studies included. The overall review design also built on previous reviews specific to adolescents through its inclusion of articles published between 2000 and 2014 since the last review was published in this area. All of the included studies were of a randomized controlled trial design; 9 of the 11 studies were given a positive quality rating. Content analysis of the study results enabled synthesis of the most frequent interventions components that were significant in the included studies.[14] However, only studies published in peer-reviewed literature were included, which may have resulted in publication bias. Studies may have been eliminated if they did not describe a multi-strategy approach in the text but may have been of a multi-strategy design. The authors also acknowledge that studies were excluded from the content analysis if they did not show at least 1 statistically significant result at a nominal level ($P < .05$). Therefore, this may not reflect the potential clinical significance of studies that were both included and excluded from the analysis. The authors also acknowledge that included studies used a variety of measurement tools including subjective measures such as self-reported dietary intake. However, although their validity has been strongly questioned recently, they offer time- and cost-efficient methods in school-based interventions.[29,30]

> Behaviorally focused education delivered by teachers with parental involvement and school food setting changes are necessary components.

IMPLICATIONS FOR RESEARCH AND PRACTICE

This review updated the existing evidence base on multi-strategy nutrition interventions focused on adolescents. It adds to existing knowledge focusing solely on adolescents and evidence that shows improvements in anthropometric and dietary intake measures. Multi-strategy nutrition education interventions appear to have statistically significant impacts on anthropometric and dietary intake measures when they are behaviorally focused, inclusive of theory-based instructional strategies and parental involvement, and delivered by school staff members and teachers, and when changes are made to the school food setting where healthy choices become the easier choices for adolescents. Recognizing the role of combining nutrition education with other strategies to support dietary behavior change is recommended. Programs for adolescents require many key features already known for effective education in children despite the different social and environmental influences on adolescents' food related behaviors, but they must be

multi-strategy in their approach. Further research may explore the sustainability of multi-strategy approaches and their long-term impact on the health and nutritional intake of the adolescents they target as well as education that is independent of the school setting.

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SUPPLEMENTARY DATA

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CONFLICT OF INTEREST

The authors have not stated any conflicts of interest.