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ORIGINAL ARTICLE

Promotion of healthy nutrition among students participating in a school food aid program: a randomized trial

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Abstract
Objectives To evaluate the potential benefits on students' eating habits, of incorporating healthy nutrition education as part of a school food aid program.
Methods 146 schools participating in the DIATROFI Program in Greece during the 2013–2014 school year were randomly allocated to the environmental intervention (received a healthy daily meal) and the multicomponent intervention (MI) group (in addition to the meal, a healthy nutrition educational program was applied). The analysis, based on 3627 pre–post intervention questionnaire pairs, was stratified for children (ages 4–11 years) and adolescents (ages 12–18 years).
Results Children participating in the MI group displayed 25 % higher odds of increasing the weekly consumption of milk/yoghurt and fruits, 61 % higher odds of improving BMI from overweight/obese to normal and 2.5 times higher odds of improving from underweight to normal. For adolescents in the MI group, the odds of increasing the consumption of vegetables were 40 % higher. In both intervention groups, approximately one in four overweight/obese adolescents reached normal weight.
Conclusions Educational programs on healthy nutrition might be considered worth implementing in the framework of school food aid programs.

Keywords School food aid program · Dietary habits · Children · School · Educational intervention

On behalf of the DIATROFI Program Research Team: The members are listed in the Acknowledgments section.

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Introduction

Healthy eating exerts a crucial role for the optimal physical growth and cognitive development of both children and adolescents (Jacka et al. 2011; Shepherd et al. 2006). Many interventions implemented at the school level focused on the improvement of student's dietary choices. Schools provide a unique environment, offering continuous and intensive contact with the students (Foltz et al. 2012; Perikkou et al. 2013; Story et al. 2006), as well as a social network of teachers and peers which influences students' eating habits in numerous ways (Khambalia et al. 2012). The most effective intervention programs have multiple components, including various methods of delivering nutritional education and promoting physical activity, such as lectures and pamphlets, family and school staff

involvement, modification of the food being provided by school canteens and supply of healthy food choices (Perikkou et al. 2013; Silveira et al. 2011; Ickes et al. 2014; Busch et al. 2013; Verstraeten et al. 2012; Yannakoulia et al. 2015; Gonzalez-Suarez et al. 2009). School-based interventions promoting healthy nutrition have been found to have different effects in children and adolescents (Van Cauwenberghe et al. 2010); therefore, stratified analysis by age group is needed to assess their effectiveness.

The "DIATROFI" Program (Yannakoulia et al. 2015; Dalma et al. 2016; Kastorini et al. 2016; Petralias et al. 2016) is a school-based program on food aid and healthy nutrition; its goal is to address the recent adverse socioeconomic condition in Greece, by providing all students of participating schools with daily free meals and promoting healthy eating through educational activities for the students and their families. The aim of the present work was to evaluate whether the provision of a healthy meal at school was a sufficient measure for promoting healthy eating habits or whether healthy eating education, both for students and their families, in addition to the meal provision, was more effective for favorably changing students' dietary habits.

Methods

Participants

The "DIATROFI" Program is being implemented since 2012; it targets students attending both elementary and secondary schools in areas of low socioeconomic status (SES). Postal codes with an average per capita taxable income (Greek Ministry of Finance data) below specific thresholds were considered to be areas of low SES. In particular, schools were categorized into three major regions, Attica, Thessaloniki and the rest of Greece. Different thresholds were set by region, so as to cover approximately 25 % of Greek public schools. After establishing initial contacts with all schools in low SES areas, a total of 1053 schools' principals, corresponding to 140,468 students, declared their willingness to participate for the 2013–2014 school year and completed the relevant application form (Fig. 1).

Depending on funding availability, a set of criteria was used to prioritize the schools that applied. These included (a) regional taxable income, (b) regional unemployment rate, (c) written reports by school principals providing estimates of the number of students facing food insecurity and special characteristics of schools (i.e., students from social institutions, Roma students, fainting episodes), (d) food insecurity measurements available from the previous school year and (e) personal interviews with teachers, parents and other school personnel, conducted by an expert in qualitative methodology, to weigh the level of food insecurity in the school. 406 schools with 61,506 students were finally selected to participate. All students of participating schools were offered the opportunity to receive the free meal, irrespective of their socioeconomic status, so as to avoid stigmatization. Parents who did not wish their child to participate provided a signed statement; only 2 % opted not to participate.

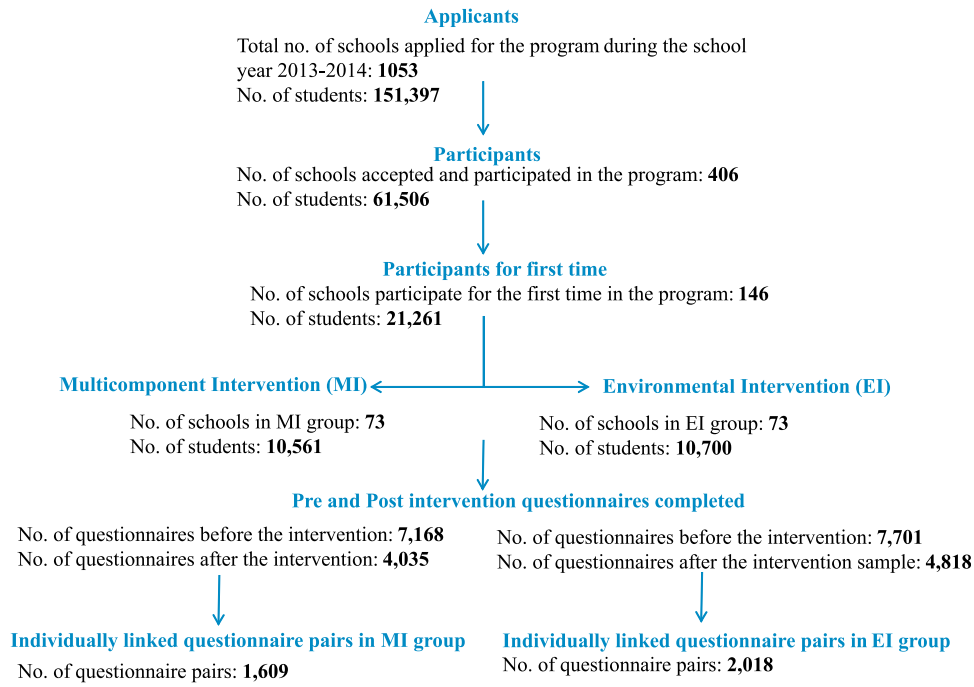

Fig. 1 Participants' enrollment; Greece; 2013–2014

One hundred and forty-six schools that participated in "DIATROFI" for the first time in the school year 2013–2014 were randomly allocated either to the environmental intervention (EI) (73 schools with 10,700 students: a healthy daily meal was provided to each student) or to the multicomponent intervention (MI) group (73 schools with 10,561 students: in addition to the provision of a daily meal, a healthy nutrition educational program was applied). All participating schools were stratified with respect to their region (Attica, Central Macedonia, rest of Greece), grade (kindergarten, elementary, gymnasium and lyceum) and special category if applicable (intercultural, evening or special needs' schools) and half of the schools in each strata were randomly assigned to each group (a computer-generated list of random numbers was used). The 146 schools included in the present analysis, where those that participated for the first time in the program, so as for students' baseline figures to represent their status without having received the intervention in the past. Note that in the framework of the general purposes of the DIATROFI Program, the remaining 260 schools not included in the analysis received also the multicomponent intervention.

Interventions

The "DIATROFI" Program has been approved and conducted under the auspices of the Greek Ministry of Education and Religious Affairs. The program has been designed and implemented to provide all students of participating schools with daily free meals while promoting healthy eating habits both for students and their families. For this reason, meals have been carefully designed to meet students' nutritional needs in accordance with age-specific nutritional guidelines.

Meals (average 435 kcal at €1.50) were high in fruit, vegetables and protein, with exclusive use of olive oil, while no preservatives, trans-fats or sweetened drinks were allowed. All students enrolled in a school participating in the DIATROFI Program received a boxed fresh meal at 10 a.m. every school day. The meal included a cereal-based food item (wholemeal sandwich, toast or pita bread filled with cheese, vegetables and occasionally chicken or turkey; or spinach pie, leek pie, sesame seed bagel or raisin bread), a fresh seasonal fruit every day and pasteurized white milk (1.5–1.8 % fat content) or yogurt with honey three times a week.

In the 73 schools assigned to the MI group, a healthy nutrition educational program was also implemented, including educational material and activities for each target group (students of different ages, parents and school staff). The program was designed on the basis of in-depth review and analysis of the existing literature and the input of 48 focus groups conducted during the 2012–2013 school year, in which all relevant stakeholders (students, parents, school staff) participated (Dalma et al. 2016). More specifically, informational posters were posted in schools, age-specific workbooks and educational games were distributed to all students, and leaflets as well as booklets were distributed to all parents and school staff belonging to the MI group. Interactive informational and cooking events were conducted by nutrition experts, athletes and volunteer chefs. Informational events for parents took place in all schools of the MI group and on average 42 % of parents participated. Informational events for students targeted adolescents and took place in all gymnasium and lyceums of the MI group (29 out of 73 schools), where all students participated. (Table 1).

Assessment

At baseline and at the end of the intervention, each parent received an anonymous questionnaire with written instructions and returned it to the school principal, who subsequently delivered all questionnaires to the research team. Students received the daily meal and the educational material irrespectively whether parents completed the questionnaire or not; parents completed a consent form for participating in the study. At the beginning of the program, we received 7168 questionnaires (response rate 68 %) from the MI and 7701 questionnaires (response rate 72 %) from the EI group. At the end of the program (school year), we received 4035 questionnaires (response rate 38 %) from the MI and 4818 from the EI group (response rate 45 %). The lower response rate at the end of the school year may be attributed to the fact that the food aid program was also coming to an end and thus parents were less motivated to complete the questionnaires. All questionnaires were completed anonymously; however, the respondents were asked to provide a personal ID number of their own choice that, along with the child's and parents' birth dates, was used to match pre- and post-intervention responses. Approximately, 66.3 % of the pre-intervention and 73.5 % of the post-intervention questionnaires hold the required information enabling us to match the data. Based on the available information, 1609 pre–post questionnaire pairs were individually linked for the MI and 2018 for the EI group.

Parents provided information regarding student's age, place of birth, type of household, education level and employment status. Parents were categorized into two groups based on whether they could provide income to their family (employees and pensioners) or not. Parental educational level was categorized as follows: (1) low: illiteracy, primary and middle school ($\leq$9 years); (2) medium: high school or corresponding technical high

Table 1 Health promotion events and materials distributed; Greece; 2013–2014

Target group	Events	Material
Children (4–11 years old)	–	Specific characters/heroes promoting a healthy lifestyle were developed: "Captain Health and the Tasty Alliance"
Kindergarten (4–5 years old), first and second grade of elementary school (6–7 years old)		Coloring book promoting healthy eating, including also rhymes and stickers
		Puzzle
		Educational posters at the school environment
Third and fourth grade of elementary school (8–9 years old)		Student workbook promoting healthy eating and physical activity, including also short rhymes, quizzes and exercises
		Educational posters at the school environment
Fifth and sixth grade of elementary school (10–11 years old)		Student workbook promoting healthy eating and physical activity, including also short rhymes, quizzes and exercises
		Quiz and knowledge board game
		Educational posters at the school environment
Adolescents (12–18 years old)	Interactive informational event by a nutrition specialist (approximately, of 1 h duration), regarding healthy eating and physical activity promotion	Electronic games promoting healthy eating
		Informational posters at the school environment
Parents/families	Interactive educational and cooking events, led by a nutrition specialist and chefs	Leaflets promoting healthy nutrition and physical activity (specifically designed for the parents/caregivers)
		Healthy recipes (distributed during the events)
Teachers	Interactive educational and cooking events, led by a nutrition specialist and chefs	Leaflets promoting healthy nutrition and physical activity (specifically designed for teachers)
Canteen staff	Interactive educational and cooking events, led by a nutrition specialist and chefs	Leaflets promoting healthy nutrition and physical activity (specifically designed for canteen staff)

school (10–12 years); and (3) high: university or higher education (≥13 years). Schools with high percentage of Roma students were identified based on the Greek ombudsman data in which are cordoned the postal codes that Roma establishments exist.

As a measure of the SES, the Family Affluence Scale (FAS) was used (Currie et al. 2008). FAS is composed of four items; a composite score was calculated for each participating student. For the present analysis, a three-point ordinal scale was used, in which FAS score 0–2, 3–5 and 6-9 indicated low, middle and high FAS affluence, respectively.

Food insecurity levels were measured using the Food Security Survey Module (FSSM) questionnaire administered to parents (Coleman-Jensen et al. 2013; Deitchler et al. 2011). FSSM contains 18 questions covering characteristic incidents of food insecurity. The score is used to determine the level of food insecurity, as categorized on a four-point scale: "food security" (score 0–2), "food insecurity without the experience of hunger" (score 3–7), "food insecurity with medium experience of hunger" (score 8–12) and "food insecurity with serious experience of hunger" (score 13–18).

From parent-reported weight and height, body mass index (BMI) was calculated (kg/m^2) and students were then categorized as lean, normal weight, overweight and obese, according to the International Obesity Task Force BMI cutoff points (Cole et al. 2000, 2007). Leisure-time physical activity was estimated through student's engagement in sports activities outside school as a binary response (yes/no).

Eating habits were assessed through a semi-quantitative food frequency questionnaire, modified version of the Bountziouka et al. (2012). Consumption frequency of selected food items was recorded, including fruits, vegetables, dairy products and cereals. The respondents were asked how often their children consume each food item and the response categories were "never/seldom", "1–3 times a month", "once a week", "2–4 times a week", "5–6 times a week", "once a day" and "more than once per day".

Statistical analysis

Chi-square analysis was used to explore relations among participants' demographic characteristics by age group and

cohort. The analysis was stratified by age group, for children (4–11 years old) and adolescents (12–18 years old). Wilcoxon signed-rank test was used to compare the weekly consumption of particular food groups before and after the intervention. Odds ratios were calculated for the probability of increasing the weekly consumption of the food groups or improving the weight status, and logistic regression analysis was performed to control for the effect of possible confounding factors, using forward stepwise model selection. Analysis was performed using SPSS 21.0 (Chicago, IL, USA).

Results

Baseline characteristics of children and adolescents are presented in Table 2. In the total sample, 53.0 % of participants were girls and 54.5 % lived in the Attica region where the capital, Athens, is located. 28.2 % of mothers and 24.6 % of fathers were born outside Greece (approximately, 44 % of them born in Albania and 25 % in Kazakhstan, Russia and Georgia); however, only 4.7 % of students were born outside Greece indicating that this population lived for several years in the country. 25.8 % did not complete high school; however, only 0.6 % of parents and 0.9 % of mothers declare they have not completed primary school. Approximately, 9 % of students lived with only one parent and 1 % in another family without their parents. 8.6 % of students were underweight, 21.9 % overweight and 6.9 % obese, while 47.7 % followed sports activities outside school. 29.1 % of families were categorized in the lowest category of the family affluence scale and 51.5 % were experiencing food insecurity, whereas 17.6 % were experiencing hunger. 11.6 % of students were attending schools located near Roma establishments.

Significant differences were observed between children and adolescents with respect to most of the socio-demographic characteristics. Children had higher obesity rates (overweight or obese children 31.8 % vs. adolescents 22.0 %, $p < 0.001$), but also higher percentage in sports activities outside school (children 50.4 % vs. adolescents 41.3 %, $p < 0.001$). On comparing the two intervention groups, statistically significant differences were observed regarding their region and paternal country of birth. In view of these differences, all variables in Table 2 have been taken into account in the logistic regression analysis.

Changes in the consumption for the food groups evaluated are presented in Table 3. Statistically significant increases observed in the MI and not in the EI group include consumption of fruits for children (MI by 5.68 %, $p = 0.002$; EI by 2.18 %, $p = 0.210$) and vegetables for both children (MI by 9.59 %, $p < 0.001$; EI by 1.59 %, $p = 0.717$) and adolescents (MI by 10.34 %, $p = 0.014$; EI by 2.16 %, $p = 0.363$). Statistically significant increases observed in both intervention groups include milk/yoghurt consumption in adolescents (MI by 8.86 %, $p = 0.051$; EI by 9.49 %, $p = 0.002$) and whole grains consumption in children and adolescents taken together (MI by 20.93 %, $p < 0.001$; EI by 17.69 %, $p < 0.001$). Consumption of milk/yoghurt in children (increased by 1.06 %, $p = 0.431$ in MI and decreased by 1.43 %, $p = 0.152$ in EI) and fruits in adolescents (increased by 6.61 % in MI, $p = 0.124$ and 3.95 % in EI, $p = 0.237$) did not change statistically significantly in any group.

After adjusting for potential confounding factors (Table 4), children belonging to the MI group displayed higher odds of increasing the consumption of milk/yoghurt (OR 1.25, 95 % CI 1.03–1.51) and fruits (OR 1.22, 95 % CI 1.02–1.46). Adolescents belonging to the MI group displayed significantly higher odds of increasing vegetable consumption (OR 1.40, 95 % CI 1.09–1.80). There were no statistically significant differences among the two groups in the probability of increasing the consumption of vegetables and whole grain in children and the consumption of milk/yoghurt, fruits and whole grains in adolescents.

With regard to body weight status, the percentage of both children (MI 61.8 % vs. EI 41.0 %, $p = 0.008$) and adolescents (MI 53.3 % vs. EI 29.7 %, $p = 0.050$) that improved their BMI from underweight to normal during the program was higher in the MI group. The percentage of children in MI whose BMI changed from overweight/obese to normal was 31.4 %, compared to 22.4 % ($p = 0.013$) in the EI group. For overweight/obese adolescents, there was no statistically significant difference (MI 24.6 % vs. EI 27.0 %, $p = 0.716$). After adjusting for potential confounding factors (Table 4), the odds of improving BMI from overweight/obese to normal for children in MI were 61 % higher than EI (95 % CI 1.12–2.31). The odds of improving BMI from underweight to normal for children participating in MI were 2.5 times the corresponding odds of EI (95 % CI 1.30–4.93). For adolescents, the odds of improving BMI from underweight to normal were of borderline significance, 2.87 times (95 % CI 0.96–8.63, $p = 0.060$) higher in MI. The probability to improve from overweight/obese to normal in adolescents did not differ among the two groups.

Discussion

School environment is a favorable setting for promoting better eating habits and healthy body weight. The effectiveness of school-based interventions, though, depends on a number of factors related either to the components of the programs or characteristics of the populations, such as SES

Table 2 Demographic characteristics by age and cohort at baseline; Greece; 2013–2014

Characteristic	Multicomponent intervention ($n = 1609$)				Environmental intervention ($n = 2018$)				Comparison between groups
	Children (4–11 years old) $n = 1187$	Adolescents (12–18 years old) $n = 422$	p	Total	Children (4–11 years old) $n = 1369$	Adolescents (12–18 years old) $n = 649$	p	Total	p
Sex (% girls)	49.3 %	59.8 %	<0.001	52.0 %	51.2 %	59.4 %	0.001	53.8 %	0.281
Region (% Attica)	68.4 %	55.9 %	<0.001	65.1 %	52.0 %	33.4 %	<0.001	46.0 %	<0.001
Maternal country of birth (% Greece)	68.5 %	76.7 %	0.002	70.6 %	69.3 %	79.9 %	<0.001	72.7 %	0.173
Paternal country of birth (% Greece)	71.7 %	79.4 %	0.002	73.7 %	73.0 %	84.7 %	<0.001	76.7 %	0.043
Child country of birth (% Greece)	96.4 %	91.8 %	<0.001	95.2 %	96.9 %	92.2 %	<0.001	95.4 %	0.752
Maternal education									0.964
Low	22.7 %	34.2 %	<0.001	25.7 %	21.0 %	36.1 %	<0.001	25.8 %	
Medium	55.8 %	46.5 %		53.4 %	55.5 %	49.7 %		53.7 %	
High	21.5 %	19.3 %		20.9 %	23.5 %	14.2 %		20.5 %	
Paternal education									0.617
Low	29.3 %	36.0 %	0.015	31.1 %	26.2 %	42.7 %	<0.001	31.5 %	
Medium	53.2 %	45.2 %		51.1 %	52.3 %	43.7 %		49.6 %	
High	17.5 %	18.8 %		17.9 %	21.5 %	13.6 %		18.9 %	
Sports outside school (% yes)	49.2 %	43.5 %	0.047	47.7 %	51.4 %	39.8 %	<0.001	47.7 %	0.982
Type of household (% Living with parents)	90.3 %	88.8 %	0.707	89.9 %	91.3 %	87.2 %	0.002	90.0 %	0.474
Weight status									0.765
Underweight	8.3 %	9.1 %	<0.001	8.5 %	9.5 %	6.9 %	<0.001	8.7 %	
Normal	59.5 %	70.5 %		62.4 %	59.2 %	70.0 %		62.7 %	
Overweight	23.4 %	16.8 %		21.6 %	23.2 %	19.9 %		22.2 %	
Obese	8.9 %	3.6 %		7.5 %	8.1 %	3.2 %		6.5 %	
Family Affluence Scale									0.634
Low	31.4 %	26.0 %	0.128	29.9 %	27.7 %	30.3 %	0.265	28.5 %	
Medium	52.5 %	56.9 %		53.7 %	55.0 %	54.9 %		55.0 %	
High	16.1 %	17.0 %		16.4 %	17.3 %	14.8 %		16.5 %	
Food Insecurity									0.210
Food security	48.2 %	44.3 %	0.419	47.1 %	52.7 %	43.8 %	<0.001	49.7 %	
Food insecurity without hunger	32.4 %	37.2 %		33.7 %	32.9 %	36.3 %		34.0 %	
Food insecurity with medium hunger	15.2 %	14.8 %		15.1 %	12.1 %	14.5 %		12.9 %	
Food insecurity with serious hunger	4.3 %	3.7 %		4.1 %	2.4 %	5.5 %		3.4 %	
School near Roma establishments (% yes)	10.4 %	14.5 %	0.027	11.5 %	16.1 %	2.0 %	<0.001	11.6 %	0.927
Number of children in the family	2.22 (0.89)	2.27 (0.95)	0.554	2.24 (0.91)	2.16 (0.83)	2.50 (1.04)	<0.001	2.27 (0.92)	0.260
Mean value (SD)									

Table 3 Percentage changes of weekly consumption of the food groups provided by the program at the end compared to the start of the intervention school year; Greece; 2013–2014

	Multicomponent intervention			Environmental intervention		
	Children (4–11 years old)	Adolescents (12–18 years old)	Total	Children (4–11 years old)	Adolescents (12–18 years old)	Total
Milk or yogurt						
% Change	1.06 %	8.86 %	2.80 %	−1.43 %	9.49 %	1.37 %
p	0.431	0.051	0.089	0.152	0.002	0.612
Vegetables						
% Change	9.59 %	10.34 %	9.81 %	1.59 %	2.16 %	1.73 %
p	<0.001	0.014	<0.001	0.717	0.363	0.402
Fruits						
% Change	5.68 %	6.61 %	5.90 %	2.18 %	3.95 %	2.60 %
p	0.002	0.124	<0.001	0.210	0.237	0.085
Whole grains						
% Change	26.55 %	13.17 %	20.93 %	11.11 %	28.78 %	17.69 %
p	<0.001	0.118	<0.001	0.042	<0.001	<0.001

Table 4 Logistic regression analysis for the probability of increasing the consumption of the food groups provided by the program and the probability of improving the weight status, separately for children and adolescents; Greece; 2013–2014

	Unadjusted		Adjusted		Statistically significant confounders:
	OR	CI	OR	CI	
Children (4–11 years old)					
Milk or yogurt	1.16*	0.99–1.37	1.25**	1.03–1.51	Sex, food insecurity, paternal country of birth, type of household
Vegetables	1.11	0.94–1.30	1.09	0.93–1.28	Sex, Roma
Fruits	1.20**	1.01–1.43	1.22**	1.02–1.46	Sex, no. of children in the family
Whole grains	1.18	0.96–1.44	1.18	0.96–1.45	Sex, paternal country of birth, Roma, sports
Underweight to normal	2.33**	1.24–4.37	2.53**	1.30–4.93	Sex, paternal country of birth
Overweight/obese to normal	1.58**	1.10–2.28	1.61**	1.12–2.31	Sex
Adolescents (12–18 years old)					
Milk or yogurt	0.83	0.65–1.07	0.82	0.64–1.06	Sex
Vegetables	1.40**	1.09–1.80	1.40**	1.09–1.80	Sex
Fruits	0.97	0.75–1.27	1.03	0.78–1.36	Sex, sports, paternal education
Whole grains	0.83	0.62–1.12	0.83	0.62–1.12	Sex
Underweight to normal	2.70*	0.99–7.39	2.87*	0.96–8.63	Sex, sports
Overweight/obese to normal	0.88	0.45–1.74	1.05	0.52–2.14	Sex, type of household

Odds ratios (OR) refer to the comparison of multicomponent versus environmental intervention groups. All variables presented in Table 2 were taken into account as possible confounders in the logistic regressions. We performed forward stepwise model selection to identify statistically significant confounders included in the final models

*** $p < 0.001$, ** $p < 0.05$, * $p < 0.10$

(Gonzalez-Suarez et al. 2009; Van Cauwenberghe et al. 2010; Reinaerts et al. 2008; Lien et al. 2014). In this study, a multicomponent intervention was found to be more effective in improving students' eating habits and body weight status, compared to a single-component, environmental intervention that included only the daily provision of a healthy meal.

A systematic review of school-based interventions in Europe provided strong evidence for multicomponent interventions regarding fruit and vegetable intake in children and limited evidence regarding dietary intake in adolescents (Van Cauwenberghe et al. 2010). On the other hand, educational interventions were considered more effective for improving dietary behavior in adolescents,

compared with children. Furthermore, limited and inconclusive evidence exists regarding the influence of environmental interventions on improving fruit and vegetables intake in children and dietary behavior in adolescents, respectively, indicating the need for further research. In this framework, our study extends previous research by providing evidence for the feasibility and the effectiveness of multicomponent interventions in children and adolescents from families facing adverse socioeconomic conditions. Related research has also indicated the importance of interventions being able to integrate and adapt to specific contexts (Lapalme et al. 2014).

In the MI group, higher odds of increasing the weekly consumption of fruits were observed for children and vegetables in adolescents. Children consume more fruits, but fewer vegetables, than adolescents, possibly because fruits are in general sweeter and juicier and perceived to taste better than vegetables (Lorson et al. 2009; Krolner et al. 2011). A study evaluating the effects of two school-based interventions, a free fruit and vegetable distribution and an intervention combining classroom nutrition education and parental involvement in six primary schools, found that both interventions were equally effective in increasing children's average fruit consumption (Reinaerts et al. 2008). Nevertheless, regarding vegetable intake, the effectiveness of the interventions differed across subgroups and was particularly effective among the oldest (fourth to sixth grade) and non-native children.

Our sample comprised students from vulnerable population groups, including children from Roma or migrant backgrounds. Children from Roma backgrounds have been found to be in need of interventions to reduce, among other risk factors, obesity (Cook et al. 2013). More research is needed to assess the effects of our intervention on these particular population groups, as other research points out to differences in terms of healthy eating behaviors (Lien et al. 2014; McAloney et al. 2014; Peltzer and Pengpid 2015).

Participation in the MI group was significantly associated with BMI improvement for children, shifting those from both the underweight and overweight/obese category to normal BMI range. A potential factor explaining the lack of significant improvement in adolescents' BMI may be the greater parental control in children's eating habits than that of adolescents. As noted in other studies, adolescents, demonstrating increased independence, are more influenced by external factors including peer interactions, food appeal and marketing (Stang and Story 2005; St George and Wilson 2012; Story et al. 2002).

In our study, we found that (in both groups taken together) 9.0 % of children were underweight, 23.3 % overweight and 8.5 % obese. For adolescents, the respective rates were 7.9 % underweight, 18.5 % overweight and 3.4 % obese. In the 2005–2009 PANACEA study, with 1125 schoolchildren in Greece participating, 27.7 % were found to be overweight and 6.3 % obese (Antonogeorgos et al. 2013). In the 2014 Greek HBSC adolescents' study (Kokkevi et al. 2015), 8.1 % of adolescents were found to be underweight, 17.4 % overweight and 3.9 % obese, which are rather similar rates to those observed in our study.

In view of the actions included in the healthy nutrition educational program, we note that 100 % of students and parents in the MI group received the educational/informational material; all teachers, canteen stuff and 42 % of parents participated in the informational events that took place in all schools in the MI group; 100 % of adolescents participated in additional informational events targeting students that took place in gymnasium and lyceums. There is the chance that the impact of the program would be larger had all parents participated in the informational events; however, attendance was not obligatory and thus high absence rates were expected, as in any related parent-involved intervention. Data from the U.S. National Household Educations Surveys Program of 2012 reveal that 26 % of parents did not attend school or any class event during the whole year, while this percentage was up to 52 % for parents with low literacy skills (Noel et al. 2013).

With regard to the limited sample linked (3627 questionnaire pairs) compared to the total (8853 post-intervention questionnaires), it must be noted that many parents hesitated to provide an ID number of their choice, although questionnaires were anonymous. As observed in Table 2, on the basis of the linked sample, there is no baseline difference among the two groups in terms of gender, BMI and socioeconomic or other characteristics (with the exception of region and paternal country of birth). Even so, taking into account that randomization was done at the school level and not at the student level, we adjust for these characteristics in the logistic regressions presented in Table 4, using model selection to account for statistically significant confounders.

A possible limitation of our analysis is the misreporting of food items, BMI and other lifestyle characteristics, due to the recall bias and the self-reported nature of the questionnaire, a known drawback in population studies (Mindell et al. 2014; Livingstone 1995).

Approximately, 25 % (25.72 % in MI group and 24.96 % in EI group) of mothers and 31.5 % (31.45 % in MI and 31.51 % in EI group) of fathers have not completed high school, the difference among the two groups being statistically insignificant. However, the percentage of illiterate parents (not completed primary education) was below 1 % in both groups. In most of the cases, a parent could not complete the questionnaire, this was completed by the other parent or another family member. Specifically, 73.7 % of questionnaires were completed by the mother, 17.6 % by the father, 1.7 % by the brother, 0.4 % by the

grandfather/grandmother and 1 % by another member of the household. Note that the completion of the questionnaires was optional and independent of the meal provision, thus there is the possibility of a lower response rate for people with low literacy skills, although we do not have data to identify such behavior.

The above errors take place both at the start and the end of the intervention and therefore are not expected to affect our estimates when reporting changes on the individually linked sample. Moreover as indicated in Table 2, these effects are non-specific to any of the groups examined, while we further controlled for socio-demographic characteristics in the statistical analysis.

Note that the pre–post intervention responses for the variables that remain constant (i.e., gender, country of birth, year of birth) were approximately 98.5 % identical in the two periods, indicating that there was low misreporting rate. There is the possibility that the educational program increased the awareness on reporting more accurately the consumption frequency of certain food items, although fruits, vegetables, milk as well as weight and height figures are widely identifiable with the general population.

Dietary habits were assessed using a modified version of a relevant food frequency questionnaire for adults (Bountziouka et al. 2012). This questionnaire was not validated in children and adolescents for energy and macronutrient intake; thus we did not assess the nutrient intake of the study populations. For conformity reasons, we decided to use the same tools and the same methodology for both children and adolescents; however, parents may not accurately report adolescents' dietary behavior due to a lack of direct and continuous involvement with adolescents' food consumption.

In reporting the above results, one must highlight the benefits stemming from the daily provision of a healthy meal at school. In the EI group, there was a statistically significant increase in the consumption of milk/yoghurt in adolescents and in whole grains in both children and adolescents. Moreover, 41 % of underweight and 22.4 % of overweight/obese children, as well as the 29.7 % of underweight and 27.0 % of overweight/obese adolescents reached normal weight. The added value of the healthy nutrition educational program was associated with increased milk/yoghurt and fruit consumption in children, increased vegetable consumption in adolescents and better results in the weight status of children, so that 61.8 % of underweight and 31.4 % of overweight/obese children had normal weight post-intervention.

In conclusion, both interventions resulted in favorable dietary changes, indicating the importance of the school as a setting for the implementation of relevant interventions. However, the multicomponent intervention was more effective in improving the eating habits and weight status, particularly in children. The findings of the present work highlight that multicomponent interventions at the school setting, including healthy nutrition education in addition to the provision of a healthy meal, are an effective policy measure for improving students' dietary choices and health status.

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Compliance with ethical standards

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Conflict of interest None.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The DIATROFI Program was conducted under the auspices of the Greek Ministry of Education and Religious Affairs. All questionnaires collected were anonymous.

Informed consent Informed consent was obtained from all individual participants.

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