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Effect of an action-research nutrition intervention on the Global Diet Quality Score of Colombian adolescents

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Abstract

Strategies to address the nutritional needs of adolescent girls and young women often focus on supplementation. In this study, an action-research approach involving a nutrition education and entrepreneurship intervention was carried out among adolescent girls and young women in poor neighborhoods of Medellín, Colombia. The intervention group significantly increased its intake of several nutrients, including energy, protein, total fat, saturated fat, monounsaturated fat, polyunsaturated fat, cholesterol, dietary fiber, calcium, zinc, and vitamins A, B2, B3, B9, and C. A significant increase was observed in the intake of the Global Diet Quality Score (GDQS) healthy food groups (other fruits, other vegetables, legumes, high-fat dairy products), accompanied by a decrease in the consumption of some unhealthy food groups (sweets and ice creams). A multivariate regression controlling for age, socioeconomic status, occupation, Household Hunger Scale, mean probability of adequacy, physical activity, and body self-perception showed that the nutrition intervention improved the total GDQS by 33% in the intervention group—a substantial improvement notwithstanding the study group's precarious social and economic conditions. We conclude that nutrition education and entrepreneurship models based on this approach may improve the dietary profile of this population and reduce future pressures from nutrition-related chronic diseases.

KEYWORDS
24-hour recall, action-research, adolescent females, diet quality, GDQS, nutritional intervention

INTRODUCTION

The quality of women's diet during their reproductive age, and especially in adolescence, has implications for their later stages in life and for the health of their future offsprings.[1] Worryingly, diets in some low- and middle-income countries, including among adolescent women, are moving toward the high consumption of energy-dense foods with low nutritional value (e.g., ultra-processed sweet and savory products, fast foods, and sugary drinks) and a reduction in the consumption of nutrient-dense foods (e.g., meat, dairy, fruits, and vegetables).[2,3] The situation facing adolescent women in Colombia follows closely with global trends: already in 2015, adolescents aged 13–17 years exhibited low consumption of healthy foods and a high consumption of sodas, fatty foods, and sweets.[4] This finding was echoed in a 2022 study[5,6] carried out by authors of this paper, which also showed risks of deficiency in the intake of energy, protein, calcium, folate, iron, fiber—paralleled by higher than recommended consumption of saturated fat and simple carbohydrates.[5]

Documented nutrition actions targeting adolescent girls and young women have mostly focused on micronutrient supplementation/fortification,[2] while the design and delivery of effective behavior change strategies to transform poor dietary habits into healthy food-based ones have received less attention. Among the educational strategies reported for adolescents are theoretical and practical workshops, dietary intake counseling using technology, promoter groups with adolescent educational leaders, and digital educational games. These strategies allow results with important changes in knowledge that favor a healthier diet.[7–9]

This paper documents the impact of an action-research (AR) intervention on the food choices of adolescent women living in Medellín, Colombia. The AR intervention used a nutrition education strategy, which had been effective elsewhere in improving food knowledge among adolescents,[5] paired with a “challenge” driven by social media to promote the role of participant adolescents as “diet influencers” among their peer groups. Changes in diets were measured pre/post interventions in a case/control cohort using the Global Diet Quality Score (GDQS).

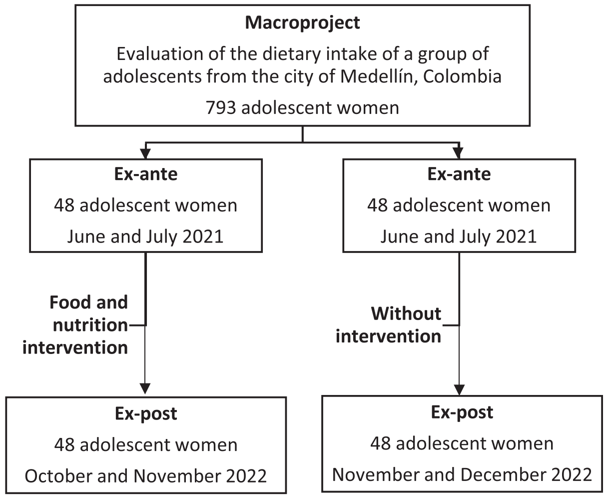

FIGURE 1 Sample selection of quasi-experimental design.

MATERIALS AND METHODS

A subgroup of 96 adolescent women was recruited from the 793 respondents to the project's initial survey (described elsewhere),[5] which aimed at evaluating the dietary pattern and the prevalence of inadequate nutrient intake among adolescents as an input for the development of future interventions in this population. Half of those ($n = 48$) had volunteered to participate in the AR intervention, which involved attending specially designed nutrition education and entrepreneurship sessions (see Supporting Information). The other half ($n = 48$) did not participate in the intervention but were randomly selected (from the initial survey respondents) by matching[7] the intervention subjects on age and place of residence (Figure 1). The sample size ($n = 48$ for both groups), for comparing two independent proportions, was calculated with a likelihood ratio test with a power of 80.25%, an α of 0.05, and a δ of 0.22.

Detailed dietary information was obtained from both groups before and after the intervention. To minimize imbalances between comparison groups due to potential confounding factors in matching variables (age and residence), the propensity score (PS, a proximity measurement approach using the exact matching algorithm) matched each treated unit with all possible units in the non-intervention group to ensure both groups were comparable on specified covariates.

Intervention

The nutrition education and entrepreneurship intervention included three stages. In the first stage, the nutrition problems identified in the initial survey were characterized, shared with participants, and the consequences for their health were explained to them.[5] In the second stage, participants were invited to attend a simple education curriculum called “CERES” (referring to the Roman goddess of agriculture, fertility, and motherhood) that included 8 weekly sessions on topics ranging from: the importance of micronutrients in adolescence; physical activity and body image; good and poor eating habits; selecting economic, healthy foods; and the preparation of healthy recipes. In the third stage, participants received training and advice on food business development, alongside topics including: developing a project mission and vision; production process, procedures, and management; branding; accounting principles; financial management and sustainability; and nutritional labeling, food handling, and food conservation. Using this acquired knowledge, participants assembled into small groups to develop individual food business projects meant to address the nutrient challenges identified in the initial survey. Proposed projects included the conception, promotion, and sale of preparations, such as healthy smoothies, nutritious breakfasts, healthy local fruit and vegetable baskets, preparations with vegetable protein, and healthy sauces and dressings. The use of social networks was encouraged to promote the products and to expand conscious eating among participants' peers. A jury assembling local academics, nongovernmental organizations, and public/private officials selected the three most promising projects. Winning projects were supported with additional funding and promoted in local markets.

Evaluation of food and nutrient intake

Dietary and sociodemographic data were collected by trained nutritionists using a validated multipass-adjusted 24-hour recall (24HR) technique, developed by the School of Nutrition of the University of Antioquia in Medellín. Ex-ante data for both groups came from the initial project survey. Ex-post data were collected among the 96 participants using the same 24HR method, applied again in nonconsecutive days of the week to adjust for inter- and intra-individual variability.[10]

Ex-post data were collected among the 96 participants using the same 24HR method, and collected again in 95% of them (5% lost to attrition) in nonconsecutive days of the week to adjust for inter- and intra-individual variability. Both subsamples were divided into two age groups (14–18 and 19–22 years of age) following subcategories established by the Energy and Nutrient Intake Recommendations for the Colombian population.[11]

To determine the amount of food ingested, geometric figures representing the weight and volume of foodstuffs and a photo album with life-size utensils were used, following a technique that had been tested in prior population studies.[12–16] The consumption of liquor, water, supplements, and nutritional supplements was also quantified to avoid overestimating nutrient deficiencies.

The 24HR data were processed in the Evaluation of Dietary Intake (EVINDI) v5 software, from the School of Nutrition and Dietetics, Universidad de Antioquia,[17] which has nutritional information from different food composition tables[18–22] and nutritional labels. The data obtained from EVINDI were processed in the Personal Computer Software for Intake Distribution Estimation (PC-SIDE) v1, available from Iowa State University's Statistical Laboratory.[23] This software adjusts for inter- and intra-individual variability[10] and estimates the best linear unbiased predictor so that the results are comparable with the estimated average requirement (EAR).[11]

Global Diet Quality Score

The GDQS is a food-based metric of diet quality that includes 25 food groups seen as important contributors to nutrient intake and/or noncommunicable disease (NCD) risk. It uses 16 healthy food groups, scored from 0 to 3 and giving more points for higher intake; seven unhealthy food groups; and two food groups (red meat, high-fat dairy products) classified as unhealthy only if consumed in excessive amounts (a score of 0 was used for both low intake and excessive intake). Summing points across all 25 food groups provides a summary measure of overall diet quality that ranges from 0 to 49. A GDQS score ≥23 is associated with a low risk of both nutrient adequacy and NCD risk, a GDQS score ≥15 and <23 indicates moderate risk, and a GDQS score <15 indicates high risk. Two GDQS submetrics were also calculated. The GDQS+ (consisting only of the "healthy" GDQS food groups) ranges from 0 to 32, and the GDQS− (consisting only of the "unhealthy" or unhealthy in excessive amounts food groups) ranges from 0 to 17.[24,25]

Statistical analysis

The adequacy of the usual energy intake, the percentage of individuals with intakes below and above the Acceptable Macronutrient Distribution Range (%AMDR), the risk of deficiency in the usual intake of dietary fiber, and the prevalence of the risk of deficiency for the usual intake of protein, vitamins, and minerals according to the EAR were determined for all participants using EVINDI-systematized data.

The descriptive analysis of the sociodemographic variables, food consumption, and GDQS was performed according to the normality criterion (Shapiro—Wilk test) and homoscedasticity (Levene test). For variables with symmetrical distribution, the mean, standard deviation, minimum, and maximum values were reported. For variables with asymmetrical distribution, the median, absolute deviation from the median, minimum, and maximum values were reported.

The Wilcoxon signed-rank test was used for nutrient comparisons between ex-ante and ex-post with and without intervention. The Mann—Whitney U test was used for nutrient comparisons for ex-post with and without intervention. These comparisons were complemented with the effect size correlation called rank-biserial correlation (rB),[26] and with the Hodges—Lehmann (HL) estimator,[27] with their respective 95% confidence intervals. A paired sample *t*-test was applied for GDQS comparisons between ex-ante and ex-post with and without intervention. An independent sample *t*-test was applied for GDQS comparisons of ex-post with and without intervention. These comparisons were complemented with Cohen's effect sizes and the difference of means, with their respective 95% confidence intervals. The McNemar test was used for GDQS classification proportions comparisons. The intraclass correlation coefficient was used for correlating the total GDQS with ex-ante and ex-post nutrients with and without intervention.

To assess the effect of the nutrition education intervention on the GDQS, a multivariate linear regression model (MVR) was performed controlling for age, socioeconomic status (SES), occupation, Household Hunger Scale (HHS), mean probability of adequacy (MPA), physical activity, and body self-perception. Tests for autocorrelation, normality, and homoskedasticity were all satisfied (p>0.05), and no problems of multicollinearity were detected in the model (tolerance >0.884). For all statistical tests, a p-value of less than 0.05 was considered significant. Data processing and analysis were performed in EVINDI v5, PC-SIDE v1, Stata 16, and Jasp 0.16.4.0 software.

Ethical aspects

This research was conducted according to the guidelines of the Declaration of Helsinki,[28] was classified as minimal risk according to Resolution 8430 of 1993 of Colombia,[29] and was approved by the bioethics committee of the University Research Headquarters (SIU).

RESULTS

When comparing groups with and without intervention before and after the intervention, there were statistically significant differences (p<0.05 using the HL estimator) found in the ex-post group for energy (Intervention, HL = −173.5), protein (Intervention, HL = −13.1; Non-intervention, HL = 6.7), total fat (Intervention, HL = −9.9), saturated (Intervention, HL = −5.4), monounsaturated (Intervention, HL = −2.4), polyunsaturated (Intervention, HL = −1.9), cholesterol (Intervention, HL = −46.3), riboflavin (Intervention, HL = −0.3), niacin (Intervention, HL = −1.4), calcium (Intervention, HL = −218.3; Non-intervention, HL = 130.2), and zinc (Intervention, HL = −1.9; Non-intervention, HL = 0.6) (Table 1).

When comparing ex-post between intervention and non-intervention, the intervention group had significantly higher consumption than the non-intervention group in protein (HL = 7.7), dietary fiber (HL = 3.5), vitamin A (HL = 173.6), riboflavin (HL: 0 = 1), folates (HL = 43.7), vitamin C (HL = 10.1), calcium (HL = 225.4), and zinc (HL = 1.5); and significantly lower consumption of polyunsaturated fat (HL = −2.66) and cyanocobalamin (HL = −0.3) (Table 1).

Significant differences in GDQS score before and after the intervention in the intervention group were found in the high-fat dairy ($p = 0.033$; rB = −0.465) and the sweets & ice cream ($p = 0.046$; rB = −0.559) food groups. When comparing ex-post between intervention and non-intervention groups, differences were found in the consumption of other fruits ($p = 0.008$; rB = 0.203), other vegetables ($p = 0.032$; rB = −0.217), legumes ($p = 0.005$; rB = 0.297), and high-fat dairy products ($p = 0.008$; rB = 0.288) (Table S1).

Significant differences were also found in the intervention group for the submetrics when comparing the ex-ante and ex-post GDQS+ score ($p = 0.044$) and total GDQS ($p = 0.019$). In the intervention group, the GDQS+ score improved by 16.4% (ex-ante = 5.5; ex-post = 6.4; MD −0.906) and the total GDQS score by 11.0% (ex-ante = 13.7; ex-post = 15.2; MD = −1.552) (Table 2). No significant differences were found in ex-post when comparing the groups with and without intervention, but the intervention group had a lower percentage of adolescents at high risk of having poor diet quality (45.8% in the intervention group vs. 54.2% in the non-intervention group), higher percentage at moderate risk (52.1% in the intervention group vs. 45.8% in the non-intervention group) and 2.1% at low risk (Table 3).

The intraclass correlation coefficient that measures the agreement between the total GDQS and the 24HR nutrients were coefficients: high and good level of agreement was found for energy, protein, total fat, cholesterol, total carbohydrates, simple carbohydrates, vitamin A, thiamine, riboflavin, pyridoxine, folates, cyanocobalamin, vitamin C, and calcium; moderate to low level of agreement was found for saturated fat, monounsaturated fat, and zinc; poor or very low level of agreement was found for polyunsaturated fat, dietary fiber, niacin, and iron (Table 4). The MVR showed that the effect of the nutrition intervention on the GDQS, controlling for age, SES, occupation, HHS, MPA, physical activity, and body self-perception was strong and highly significant ($\beta_e = 0.3289$; $p = 0.027$; 95% CI = 0.0371, 0.6206) (data not shown).

DISCUSSION

Compared to the non-intervention group, the intervention group increased its intake of several nutrients, including energy, protein, total fat, saturated fat, monounsaturated fat, polyunsaturated fat, cholesterol, dietary fiber, vitamin A, vitamin C, riboflavin, niacin, calcium, zinc, and folate. When consumption was evaluated according to the GDQS food groups, there was an increase in the intake of other fruits, other vegetables, legumes, and high-fat dairy products, and there was a decrease in the consumption of sweets and ice cream, all of which favored an increase in the average GDQS+ and total GDQS scores. Controlling for SES, body self-perception, and physical activity, the nutrition education intervention improved the total GDQS by 33%. It thus leads us to conclude that the pedagogical approach and the educational strategies implemented through the CERES school contributed to meaningful changes in participants' dietary intake as well as in their GDQS score. Sharing and discussing with participants the dietary and nutritional problems identified by the initial study, agreeing on a plan to act, training and empowering the participants, and developing strategies that responded to their interests improved the intake of nutrients and healthy foods.

We did not find other studies with similar results that measured effect size; however, comparisons were made with other studies with similar results that applied other inferential statistical methods. In a 12-week experiment by Chung and Fong,[8] using e-learning to carry out nutrition education ($n = 45$ experimental group and $n = 50$ control group), all adolescents received six lessons on basic concepts of healthy eating and lifestyle, and they sent photos of the food consumed daily to a system designed for this purpose. Only the experimental group received feedback from trained personnel on energy intake in relation to their needs, information on the nutrients of each food consumed, indications of which food was more or less healthy, and motivation to make better choices to meet the recommendations of the national dietary guidelines. The experimental group showed significantly higher scores post treatment than the control group in the intake of all nutrients evaluated. The researchers concluded that nutrition education with sustained feedback can improve nutritional behaviors.

Similarly, a systematic review by Murimi et al.[30] that included eight studies of nutrition education among adolescents identified characteristics associated with successful interventions such as: the inclusion of environmental changes (e.g., offering a balanced breakfast, modifying school cafeteria offerings for healthy foods specific to the region, and offering incentives for selecting healthier foods); conducting activities appropriate for the age group (e.g., role-playing, peer-led discussions, health fairs, sports games, nutrition education based on cosmetic content, and the use of technology); identifying specific behaviors that require modification; assigning activities containing intervention objectives on a frequent basis (i.e., weekly or biweekly and lasting between 30 and 60 min) for at least 6 months; involving parents; and training implementers to ensure fidelity. The results of our study support those findings. Although we were not able to measure the sustainability of the intervention, the young women were accompanied during the training process in the nutrition and entrepreneurship component as well as in the process of formulating and developing their projects as well as socialization with the community. Other studies[31] have reported that it is difficult for young women to maintain their participation after the incentives are provided. Other aspects to consider are that the purchase and choice of food at home depends on the parents,[32] for which reason the education of the adults responsible for food in the household needs to be encouraged.

TABLE 1 Comparing energy and nutrients.

Nutrient	Intervention			Non-intervention			Comparing ex-post intervention and non-intervention***
	ex-ante*	ex-post*	*p*-value**	ex-ante*	ex-post*	*p*-value**	
Energy (kcal)	1710 ± 131 [1240; 2287]	1826 ± 246 [1156; 2810]	0.014 [−0.405]; −173.5 (−300.6; −34.0)	1761 ± 160 [1198; 2512]	1706 ± 380 [548; 4002]	0.418 [−0.136]; −77.7 (−256.5; 98.6)	0.395 [0.102]; 85.5 (−117.3; 276.9)
Protein (g)	45.9 ± 1.5 [40.7; 51.8]	58.0 ± 6.8 [37.3; 88.8]	<0.001 [−0.952]; −13.1 (−16.3; −9.7)	58.5 ± 9.8 [27.6; 110.5]	49.4 ± 9.2 [19.6; 95.7]	0.011 [0.417]; 6.7 (1.8; 11.7)	0.007 [0.316]; 7.7 (2.3; 12.8)
Total fat (g)	52.8 ± 5.8 [36.5; 78.8]	62.6 ± 14.6 [33.3; 103.8]	0.002 [−0.500]; −9.9 (−15.6; −3.6)	66.1 ± 4.5 [46.3; 96.5]	62.8 ± 14.2 [19.0; 146.39]	0.572 [−0.095]; −2.0 (−10.3; 5.0)	0.411 [−0.098]; −3.9 (−13.3; 5.2)
Saturated fat (g)	20.76 ± 3.34 [11.99; 32.65]	26.62 ± 5.77 [14.46; 39.95]	<0.001 [−0.624]; −5.4 (−7.8; −2.9)	26.48 ± 3.35 [15.14; 48.17]	23.48 ± 5.68 [5.90; 53.36]	0.196 [0.216]; 1.9 (−1.0; 4.7)	0.305 [0.122]; 1.8 (−1.8; 5.3)
Monounsaturated fat (g)	18.91 ± 1.86 [13.40; 27.34]	20.41 ± 4.48 [11.08; 36.6]	0.028 [−0.362]; −2.4 (−4.4; −0.2)	21.43 ± 2.27 [14.9; 30.01]	21.08 ± 5.2 [6.55; 45.46]	0.461 [−0.124]; −0.9 (−4.1; 1.5)	0. 495 [−0.082]; −1.1 (−4.4; 2.2)
Polyunsaturated fat (g)	9.76 ± 1.86 [4.30; 23.93]	11.40 ± 3.04 [4.80; 21.8]	0.010 [−0.422]; −1.9 (−3.4; −0.4)	14.07 ± 0.95 [11.15; 17.57]	14.82 ± 4.81 [2.81; 37.50]	0.586 [−0.092]; −0.6 (−2.6; 1.3)	0.020 [−0.275]; −2.7 (−5.1; −0.4)
Cholesterol (mg)	264 ± 69 [114; 462]	312 ± 9 [289; 346]	<0.001 [−0.544]; −46.3 (−73.8; −19.3)	300 ± 49 [99; 619]	320 ± 72 [143; 652]	0.287 [−0.179]; −19.2 (−56.6; 14.7)	0.784 [−0.033]; −7.1 (39.3; 29.4)
Total carbohydrates (g)	256.6 ± 31.4 [154.0; 409.8]	253.8 ± 32.7 [190.3; 375.5]	0.315 [−0.168]; −9.0 (27.5; 9.7)	241.9 ± 28.0 [153.4; 347.6]	243.2 ± 49.3 [62.4; 596.2]	0.586 [−0.092]; −5.5 (−28.4; 18.0)	0.207 [0.150]; 18.7 (9.0; 46.2)
Simple carbohydrates (g)	54.3 ± 8.1 [29.2; 79.8]	45.7 ± 11.2 [12.8; 91.0]	0.020 [0.383]; 6.3 (1.0; 11.0)	55.7 ± 8.4 [25.8; 87.0]	41.2 ± 10.2 [16.1; 86.7]	<0.001 [0.702]; 12.2 (7.4; 17.3)	0.115 [0.188]; 5.0 (−1.5; 11.8)
Dietary fiber (g)	14.8 ± 1.2 [11.7; 21.6]	15.3 ± 1.7 [8.2; 24.3]	0.407 [−0.139]; −0.4 (−1.3; 0.5)	10.8 ± 1.7 [5.5; 18.1]	11.6 ± 3.7 [1.9; 33.7]	0.160 [−0.235]; −1.3 (−3.2; 0.5)	0.002 [0.361]; 3.5 (1.4; 5.3)
Vitamin A (ER)	514 ± 73 [279; 870]	471 ± 39 [363; 607]	0.002 [0.503]; 56.8 (21.3; 96.2)	799 ± 181 [291; 1611]	298 ± 81 [84; 750]	<0.001 [0.980]; 484.7 (398.0; 579.8)	<0.001 [0.728]; 173.6 (137.4; 209.7)
Thiamine (mg)	0.77 ± 0.25 [0.29; 8.75]	0.95 ± 0.23 [0.50; 1.95]	0.200 [−0.214]; −0.1 (−0.3; 0.1)	0.83 ± 0.09 [0.53; 1.30]	0.92 ± 0.25 [0.25; 8.81]	0.023 [−0.376]; −0.1 (−0.3; −0.0)	0.628 [0.058]; 0.0 (−0.1; 0.2)

(Continues)

TABLE 1 (Continued)

Nutrient	Intervention			Non-intervention			Comparing ex-post intervention and non-intervention***
	ex-ante*	ex-post*	*p*-value**	ex-ante*	ex-post*	*p*-value**	
Riboflavin (mg)	0.94 ± 0.26 [0.23; 4.27]	1.30 ± 0.12 [0.91; 1.77]	0.001 [−0.524]; −0.3 (−0.4; −0.1)	1.09 ± 0.25 [0.28; 2.37]	1.10 ± 0.19 [0.49; 3.11]	0.315 [−0.168]; −0.1 (−0.2; 0.1)	0.032 [0.254]; 0.1 (0.0; 0.2)
Niacin (mg)	9.8 ± 2.0 [4.9; 29.1]	11.5 ± 1.5 [6.9; 17.5]	0.008 [−0.434]; −1.4 (−2.4; −0.3)	11.6 ± 1.3 [6.7; 17.7]	10.9 ± 2.6 [3.0; 36.7]	0.835 [0.036]; 0.1 (−1.0; 1.2)	0.333 [0.115]; 0.8 (−0.7; 2.1)
Pyridoxine (mg)	1.30 ± 0.43 [0.51; 9.89]	1.32 ± 0.06 [1.12; 1.61]	0.996 [−0.002]; −0.0 (−0.2; 0.2)	1.41 ± 0.22 [0.82; 2.62]	1.31 ± 0.38 [0.40; 10.4]	0.673 [0.071]; 0.0 (−0.1; 0.2)	0.751 [0.038]; 0.0 (−0.1; 0.2)
Folates (mcg EFD)	219 ± 53 [113; 437]	302 ± 16 [238; 386]	<0.001 [−0.844]; −85.2 (−107.6; −62.0)	205 ± 7 [175; 240]	260 ± 71 [60; 679]	<0.001 [−0.662]; −62.0 (−98.8; −32.1)	0.004 [0.336]; 43.7 (15.3; 77.0)
Cyanocobalamin (mcg)	2.32 ± 0.21 [1.54; 3.18]	1.82 ± 0.02 [1.71; 1.94]	<0.001 [0.952]; 0.5 (0.4; 0.6)	4.57 ± 0.66 [2.60; 7.32]	2.10 ± 0.41 [1.01; 4.64]	<0.001 [0.991]; 2.4 (2.1; 2.7)	<0.001 [−0.421]; −0.3 (−0.5; −0.2)
Vitamin C (mg)	68 ± 6 [48; 104]	69 ± 0 [69; 69]	0.260 [−0.189]; −1.7 (−4.4; 1.0)	68 ± 7 [45; 91]	59 ± 23 [8; 161]	0.239 [0.197]; 5.4 (−3.7; 14.6)	0.013 [0.292]; 10.1 (5.1; 15.1)
Calcium (mg)	302 ± 144 [56; 828]	574 ± 43 [391; 795]	<0.001 [−0.811]; −218.3 (−284.5; −138.0)	471 ± 56 [286; 640]	323 ± 67 [213; 640]	<0.001 [0.845]; 130.2 (93.7; 167.2)	<0.001 [0.865]; 225.4 (182.3; 265.3)
Iron (mg)	9.8 ± 1.4 [5.3; 18.7]	10.2 ± 1.1 [6.9; 22.4]	0.330 [−0.163]; −0.4 (−1.3; 0.5)	9.1 ± 1.9 [2.7; 22.5]	9.7 ± 2.0 [2.7; 21.7]	0.042 [−0.337]; −1.1 (−2.0; −0.0)	0.231 [0.142]; 0.5 (−0.3; 1.5)
Zinc (mg)	5.73 ± 0.57 [4.17; 7.81]	7.68 ± 0.79 [5.10; 10.84]	<0.001 [−0.998]; −1.9 (−2.4; −1.5)	7.17 ± 1.46 [2.21; 17.40]	6.09 ± 0.99 [2.74; 10.51]	0.028 [0.364]; 0.6 (0.1; 1.6)	<0.001 [0.511]; 1.5 (0.9; 2.1)

*Data were calculated with the best linear unbiased predictor and are reported as median ± median absolute deviation [minimum value; maximum value].
**p-value Wilcoxon signed-rank [effect size: rank-biserial correlation]; Hodges–Lehmann estimate (95% CI).
***p-value Mann–Whitney U [effect size: rank-biserial correlation]; Hodges–Lehmann estimate (95% CI).

Some studies[7,33] suggest that food and nutrition education has been shown to be effective in improving knowledge and behavior in terms of food choice and consumption, especially in children and adolescents who are at a stage of psychosocial formation in which the establishment of healthy eating habits can be maintained into adulthood. This effect has been demonstrated in experimental interventions,[7] and adolescents have also reported increased knowledge and a change in eating behaviors when education is provided by trained personnel.[7] In addition, adolescents have reported that most of the nutrition information currently received comes from non-nutrition professionals.[33]

Achieving transformations in food and nutrition practices with adolescent women in risky territories and in COVID-19 post-pandemic times, requires researchers to analyze the contexts, settings, and environments where the participants live and grow up. According to Arango et al.,[34] changing an unhealthy educational environment for a healthy one requires involving people from all sectors of the community. Therefore, the educational and innovation process developed in this study was based on a Flexible Learning Model[34] that includes training and learning levels, that is, understanding (theoretical), application of knowledge to reality (practical), communication (ability to replicate with other actors and contexts), and a system based on competencies and the needs of each participant. The results achieved reinforce the need to make this subject a central pillar and promote transformations from the context of the participants to generate transformations that

TABLE 2 Comparison of Global Diet Quality Scores.

GDQS	Intervention ex-ante*	Intervention ex-post*	Intervention *p*-value**	Non-intervention ex-ante*	Non-intervention ex-post*	Non-intervention *p*-value**	Comparing ex-post intervention and non-intervention***
GDQS total	13.7 ± 3.6 [6.0; 20.3]	15.2 ± 3.3 [8.5; 24.3]	0.019 [−0.350]; −1.6 (−2.8; −0.3)	13.5 ± 3.2 [5.0; 20.3]	13.9 ± 3.6 [3.0; 21.5]	0.523 [−0.093]; −0.4 (−1.7; 0.9)	0.069 [0.375]; 1.3 (−0.1; 2.7)
GDQS +	5.5 ± 2.3 [1.0; 10.8]	6.4 ± 2.6 [1.0; 12.3]	0.044 [−0.298]; −0.9 (−1.8; −0.0)	5.1 ± 2.2 [1.0; 9.3]	5.1 ± 2.5 [0.0; 11.3]	0.835 [0.030]; 0.1 (−0.8; 1.0)	0.012 [0.523]; 1.4 (0.3; 2.4)
GDQS –	8.2 ± 2.3 [3.0; 12.0]	8.8 ± 2.2 [4.0; 14.0]	0.180 [−0.197]; −0.6 (−1.6; 0.3)	8.4 ± 2.1 [3.0; 12.0]	8.9 ± 2.5 [2.0; 13.0]	0.267 [−0.162]; −0.5 (−1.5; 0.4)	0.896 [−0.027]; −0.1 (−1.0; 0.9)

*Data are reported in mean ± standard deviation [minimum value; maximum value].
**p-value paired sample t-test [Cohen's effect sizes]; Mean difference (95% CI).
***p-value independent sample t-test [Cohen's effect sizes]; Mean difference (95% CI).

TABLE 3 Comparison of the Global Diet Quality Score classification.

GDQS classification	Intervention ex-ante*	Intervention ex-post*	Intervention *p*-value**	Non-intervention ex-ante*	Non-intervention ex-post*	Non-intervention *p*-value**	Comparing ex-post intervention and non-intervention**
High risk	58.3 (28)	45.8 (22)	0.220	60.4 (29)	54.2 (26)	0.539	0.410
Moderate risk	41.7 (20)	52.1 (25)	0.307	39.6 (19)	45.8 (22)	0.539	0.537
Low risk	0.0 (0)	2.1 (1)	0.313	0.0 (0)	0.0 (0)	–	0.313

*Data are reported as % (n).
**p-value McNemar test.

last over time and even be adopted by other members of the family and the community.

It is also instructive to compare the GDQS scores obtained in this study with those from other locations. The mean total GDQS scores in this study were lower than those reported from the Mexican National Health and Nutrition Survey 2012–2016[35] (total GDQS = 15.8) which included 1411 women aged 15–29 years; and substantially lower than a study in India,[36] which observed 3041 women of reproductive age (total GDQS = 23.0). Unlike these studies, our sample consisted of a specific group of adolescent women living in the poorest *barrios* of Medellín who may have been singularly disfavored economically and socially compared to the participants in the other studies. That said, the other analyses carried out in addition to the GDQS on our survey data—using the NOVA Screener method[6] and Optifood—confirmed the alarming trends identified in this paper.[37] The lower GDQS total mean scores of this study compared to others are increasing but they have been compounded in recent years by the COVID-19 pandemic first and then by the 2022 inflation that had particularly pernicious effects on the poorer segments of Colombian society. No matter the root cause, the low GDQS scores witnessed in our sample should not be ignored as they reflect not only dismal nutrition practices but also the severity of future NCD onslaughts in this population group.

The strengths of this study were the quality of the data used to characterize diets; the extensive institutional collaboration that facilitated the innovative AR intervention model used to develop solutions; and the engagement and ownership of the process by adolescent women themselves. Factors that limited the reach of this study are first the small sample size of the intervention group. A larger sample of treatments and controls would likely have strengthened the results obtained. Second, the short funding period after the intervention did not allow the authors to monitor over time the sustainability of the participants' initiatives, whether on a commercial basis or on the retention of healthy eating habits among participants.

CONCLUSION

Two main lessons may be derived from this study. First, it demonstrated that nutrition education may help promote healthier food and nutrition practices, even under precarious social and economic situations. A pedagogical process based on solid data, a reflexive reading of the contexts where the participants live, the promotion of self-esteem, and the involvement of other community actors and advisors can generate actions that stand a chance of success, especially if those actions are formulated and owned by adolescents themselves.[32] Second, the study established for the first time (to our knowledge) that the various GDQS metrics may be used as tools to not only monitor changes over time following an intervention but also to make fine distinctions into what these changes entail. In this case, for instance, it showed that positive

TABLE 4 Correlation between total Global Diet Quality Score and intake of nutrients.

	Intervention		Non-intervention	
Nutrient	Ex-ante	Ex-post	Ex-ante	Ex-post
Energy (kcal)	0.958	0.920	0.961	0.793
Protein (g)	0.966	0.879	0.811	0.752
Total fat (g)	0.892	0.767	0.940	0.666
Saturated fat (g)	0.415	0.504	0.679	0.349
Monounsaturated fat (g)	0.383	0.276	0.635	0.297
Polyunsaturated fat (g)	0.177	0.150	0.009	0.001
Cholesterol (mg)	0.795	0.996	0.806	0.824
Total carbohydrates (g)	0.914	0.934	0.933	0.766
Simple carbohydrates (g)	0.818	0.587	0.833	0.650
Dietary fiber (g)	0.082	0.167	0.009	0.065
Vitamin A (ER)	0.876	0.967	0.801	0.720
Thiamine (mg)	0.834	0.904	0.888	0.856
Riboflavin (mg)	0.843	0.901	0.874	0.869
Niacin (mg)	0.117	0.265	0.073	0.032
Pyridoxine (mg)	0.825	0.901	0.877	0.845
Folates (mcg EFD)	0.784	0.977	0.990	0.684
Cyanocobalamin (mcg)	0.828	0.894	0.767	0.846
Vitamin C (mg)	0.924	0.993	0.911	0.523
Calcium (mg)	0.554	0.955	0.939	0.845
Iron (mg)	0.200	0.386	0.292	0.241
Zinc (mg)	0.688	0.693	0.507	0.659

Note: Data are intraclass correlation coefficient: 0–0.2: poor or very low agreement; 0.2–0.4: low agreement; 0.4–0.6: moderate agreement; 0.6–0.8: substantial agreement; 0.8–1: excellent or near perfect agreement.

eating habits were acquired by "intervened" participants, but also that unhealthy habits did not disappear altogether from that group.

Jointly, these results are important to policymakers as they clearly point to the nutritional vulnerability faced by adolescent girls and young women in Medellín's poor *barrios* and to the long-term implications that they may have on their health and on the health of future generations, thus signaling how a lack of action will increase future NCD pressures on individuals and on the public health system. Our results also show that a model for action based on nutrition education can improve the dietary behaviors of target groups.

AUTHOR CONTRIBUTIONS

All authors contributed to the conceptualization of the study, reviewed, and approved the manuscript. S.L.R.-M., N.C.G., and G.B. were responsible for project coordination and data collection. S.L.R.-M., M.C.G.Q., C.H.Á., and G.B. coordinated the process of recruitment and education in the intervention. S.L.R.-M., N.C.G., V.C., and G.B. were involved in analysis and interpretation. G.B. managed project funding and liaison of participating entities.

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COMPETING INTERESTS

There are no competing interests.

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REFERENCES

1. Velasteguí, J., Hernández, M., Real, J., Roby, A., Alvarado, H., & Haro, A. (2018). Perinatal complications associated with pregnancy in adolescents from Atacames. *Revista Cubana De Medicina General Integral*, *34*, 37–44.
2. Keats, E. C., Rappaport, A. I., Shah, S., Oh, C., Jain, R., & Bhutta, Z. A. (2018). The dietary intake and practices of adolescent girls in low- and middle-income countries: A systematic review. *Nutrients*, *10*(12), 1978.
3. Pizarro, F. (2022). Is an iron, zinc and calcium supplement possible? In Microminerals: State of the art, version 2.0.
4. Colombian Institute of Family Welfare, Profamilia, & National Health Institute. (2018). *National survey of the food and nutritional situation in Colombia: ENSIN 2018*. Colombian Institute of Family Welfare.
5. Restrepo-Mesa, S. L., Correa Guzmán, N., Manjarrés Correa, L. M., Duque Franco, L., & Bergeron, G. (2023). Food and nutrient intake of adolescent women in Medellín, Colombia. *Annals of the New York Academy of Sciences*, *1528*, 77–84.
6. Correa-Madrid, M. C., Correa Guzmán, N., Bergeron, G., Restrepo-Mesa, S. L., & Cediel, G. (2023). Validation of the NOVA score for the consumption of ultra-processed foods by young women of Medellín, Colombia. *Annals of the New York Academy of Sciences*, *1528*, 69–76.
7. Macías-Matos, C., Basabe-Tuero, B., Pita-Rodríguez, G., Sanabria-González, S. A., Mercader-Camejo, O., & Herrera-Javier, D. (2020). Intervención nutricional participativa en adolescentes de enseñanza media del municipio Habana Vieja. *Cuban Journal of Public Health*, *46*(3), e2039.
8. Chung, L., & Fong, S. (2018). Role of behavioural feedback in nutrition education for enhancing nutrition knowledge and improving nutritional behaviour among adolescents. *Asia Pacific Journal of Clinical Nutrition*, *27*(2), 466–472.
9. De Oliveira, J. F., Lagares, É., Belo, V., Romano, M. C., & Araújo, A. (2020). Impact of software for mobile devices on the behavior of adolescents in obesity prevention. *Texto & Contexto—Enfermagem*, *29*, e20190022.
10. Institute of Medicine. (2000). Minimizing potential errors in assessing group and individual intakes. In *DRI Dietary Reference Intakes Applications in Dietary Assessment*. National Academy of Sciences.
11. Ministry of Health and Social Protection from Colombia. (2016). *Resolution 3803 of 2016: Recommendations for Energy and Nutrient Intake—RIEN*. Ministry of Health and Social Protection from Colombia.
12. Manjarrés, L. M. (2008). Methods for refining the collection of dietary intake in population-based studies. *Perspectives in Human Nutrition*, *9*(2), 155–163.
13. Cadavid, M., Restrepo, M., Rivillas, J., Sepúlveda, M., Manjarrés, L., & Estrada, A. (2006). Concordance between the direct weight of ingested food portions and the estimation of weights with the help of geometric figures and the technique of weights memorized by the interviewer, in children aged 5–9 years. *Perspectives in Human Nutrition*, *15*(1), 31–43.
14. Colombian Institute of Family Welfare, Profamilia, National Health Institute, University of Antioquia, & Pan American Health Organization. (2006). *National survey of the food and nutritional situation in Colombia: ENSIN 2005*. Panamerican Signatures and Forms, S. A.
15. MANÁ, & University of Antioquia. (2019). *Food and nutrition profile of Antioquia 2019*. University of Antioquia.
16. Hoyos, G. (2015). *Food and nutritional security profile of Medellín and its corregimientos, 2015*. Mayor's Office of Medellín.
17. Manjarrés, L., Hernández, J., & Cárdenas, D. (2015). *Evaluation Program of Dietary Intake (EVINDI) v5*. University of Antioquia.
18. Quintero, D., Alzate, M., & Moreno, S. (1990). *Table of Food Composition*. Nutritional Care Center.
19. Quintero, D., & Escobar, L. (2001). *Table of Food Composition* (2nd ed.). Nutritional Care Center.
20. Colombian Institute of Family Welfare. (2015). *Table of Composition of Colombian Foods* (2nd ed.). Colombian Institute of Family Welfare.
21. Food and Agriculture Organization. (2022). *International Network of Food Data System: INFOODS*. Food and Agriculture Organization.
22. United States Department of Agriculture. (2022). *FoodData Central*. United States Department of Agriculture.
23. Carriquiry, A. (2022). *PC-Side*. Iowa State University.
24. Bromage, S., Batis, C., Bhupathiraju, S. N., Fawzi, W. W., Fung, T. T., Li, Y., Deitchler, M., Angulo, E., Birk, N., Castellanos-Gutierrez, A., He, Y., Fang, Y., Matsuzaki, M., Zhang, Y., Moursi, M., Kronsteiner-Gicevic, S., Holmes, M., Isanaka, S., Kinra, S., … Willett, W. C. (2021). Development and validation of a novel food-based Global Diet Quality Score (GDQS). *Journal of Nutrition*, *151*(2), 75S–92S.
25. Bromage, S., Zhang, Y., Holmes, M. D., Sachs, S. E., Fanzo, J., Remans, R., Sachs, J. D., Bâtis, C., Bhupathiraju, S. N., Fung, T. T., Li, Y., Stampfer, M. J., Deitchler, M., Willett, W. C., & Fawzi, W. W. (2021). The Global Diet Quality Score is inversely associated with nutrient inadequacy, low midupper arm circumference, and anemia in rural adults in ten sub-Saharan African countries. *Journal of Nutrition*, *151*(2), 119S–1129S.
26. Kerby, D. (2014). The simple difference formula: An approach to teaching nonparametric correlation. *Comprehensive Psychology*, *3*, 1–9.
27. Abid, M., Abbas, N., Nazir, H., & Lin, Z. (2016). Enhancing the mean ratio estimators for estimating population mean using non-conventional location parameters. *Revista Colombiana De Estadística*, *39*, 63–79.
28. World Medical Association. (2018). Declaration of Helsinki: Ethical principles for medical research involving human subjects.
29. Ministry of Health and Social Protection from Colombia. (1993). *Resolution 8430 of 1993: By which the scientific, technical and administrative standards for health research are based*. Ministry of Health and Social Protection from Colombia.
30. Murimi, M., Moyeda-Carabaza, A., Nguyen, B., Saha, S., Amin, R., & Njike, V. (2018). Factors that contribute to effective nutrition education interventions in children: A systematic review. *Nutrition Reviews*, *76*(8), 553–580.
31. Thomaes, S., Grapsas, S., Van of Wetering, J., Spitzer, J., & Poorthuis, A. (2023). Green teens: Understanding and promoting adolescents' sustainable engagement. *One Earth*, *6*, 352–361.
32. Bryan, C. J., Yeager, D. S., & Hinojosa, C. P. (2019). A values-alignment intervention protects adolescents from the effects of food marketing. *Nature Human Behaviour*, *3*, 596–603.
33. Partida, S., Marshall, A., Henry, R., Townsend, J., & Toy, A. (2018). Attitudes toward nutrition and dietary habits and effectiveness of nutrition education in active adolescents in a private school setting: A pilot study. *Nutrients*, *10*(9), 1260.
34. Arango, M., Nimnicht, G., Peñaranda, F., & Acosta, A. (2005). *Veinte años de experiencia: Un informe sobre el programa PROMESA en Colombia*. Bernard van Leer Foundation.
35. Castellanos-Gutiérrez, A., Rodríguez-Ramírez, S., Bromage, S., Fung, T., Li, Y., Bhupathiraju, S., Deitchler, M., Willett, W., & Batis, C. (2021). Performance of the Global Diet Quality Score with nutrition and health outcomes in Mexico with 24-h recall and FFQ data. *Journal of Nutrition*, *151*(2), 143S–151S.
36. Matsuzaki, M., Birk, N., Bromage, S., Bowen, L., Batis, C., Fung, T. T., Li, Y., Stampfer, M. J., Deitchler, M., Willett, W. C., Fawzi, W. W., Kinra, S., & Bhupathiraju, S. N. (2021). Validation of Global Diet Quality Score among nonpregnant women of reproductive age in India: Findings from the Andhra Pradesh Children and Parents Study (APCAPS)

and the Indian Migration Study (IMS). *Journal of Nutrition*, *151*(2), 101S–109S.

37. Knight, F., Kuri, S., Damu, C., Mejia, C., Correa Guzmán, N., Bergeron, G., & Restrepo-Mesa, S. L. (2023). Exploring the potential of meeting adolescent girls' nutrient needs in urban Colombia using food-based recommendations. *Annals of the New York Academy of Sciences*, *1528*, 58–68.

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