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The effect of nutritional and lifestyle education intervention program on nutrition knowledge, diet quality, lifestyle, and nutritional status of Croatian school children

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Introduction: Nutrition education during adolescence has proven effective in increasing knowledge, attitudes, and practices in the diet. The Mediterranean diet has proven health benefits and is proposed as a model of a sustainable diet that is beneficial for health and the environment. Its promotion with the educational program can have a significant effect on improvements in nutrition knowledge, diet quality, and nutritive status of adolescents for their healthy adulthood.

Objective: This study aimed to investigate the effect of the educational program on the nutrition knowledge, diet quality, lifestyle, and nutritional status of school children from the littoral part of Croatia.

Methods: An education-based intervention study was carried out on 2,709 schoolchildren aged 10–12 years (educated/control group: 2617/92). The questionnaire about sociodemographic, anthropometric, dietary, physical activity, screen time, sleep habits, and nutrition knowledge was assessed at the baseline and after a 6- to 9-month follow-up for the medium-term effect of education. Nutrition knowledge was provided after 3 weeks for the short-term education effect assessment.

Results: Educated schoolchildren achieved a significant increase in nutrition knowledge (+75.5%), expressed as a short-term effect of the education and maintained at the 6- to 9-month follow-up (+66.8%, $p < 0.001$). Follow-up of children significantly improved their nutritional status (underweight −56.6%, normal weight 24.8%, overweight −22.1%, and obesity −57.5%) and physical activity engagement (+13.2%). The proportion of children with a diet highly adhering to the Mediterranean diet significantly doubled (+105.0). Those children with the highest nutrition knowledge at the follow-up significantly improved their nutritional status (+218.9%), participated in organized sports (+204.7%), and had a diet that highly adhered to the MD (+291.8%).

Conclusion: A significantly good medium-term effect of education-based nutrition and lifestyle intervention program on nutrition knowledge, diet quality, lifestyle, and nutritional status of schoolchildren aged 10–12 years was shown. The educational program promoted a Mediterranean diet and lifestyle as a healthy

and sustainable way of living, important for children's future health and wellbeing. New research-based approaches are needed for making children more aware and capable of handling the complexity of sustainable living.

KEYWORDS

school children, educational program, nutrition knowledge, diet, habits, lifestyle, Mediterranean diet (MD), sustainability

1. Introduction

Better nutrition knowledge is associated with healthier dietary choices, which may have a positive influence on health (Kresić et al., 2009; Sichert-Hellert et al., 2011). Knowledge about healthy eating and diet established during childhood is unlikely to be changed during the period of youth (Lee et al., 2006), but if maintained in adulthood, may prevent diseases related to unhealthy dietary habits, especially obesity and associated metabolic complications. Over the past few decades, the prevalence of overweight and obesity among children and adolescents aged 5–19 years has increased 4.5 times worldwide (World Health Organization, 2022). This is probably aggravated by the recent COVID-19 pandemic, as testified by significant increases in body weight, BMI, waist circumference, or body fat, even among the 59.7% of surveyed children and adolescents worldwide (Karatzi et al., 2021). In fact, the prevalence of overweight and obesity has increased by 2–13% in different countries across the world (Lobstein et al., 2022), while in Croatia, the prevalence increased by 3% in children aged 10–15 years during the COVID-19 lockdown period (Kendel Jovanović et al., 2021). Unsuccessfully addressing childhood obesity can be a significant problem because childhood obesity has been shown to be associated with metabolic complications and chronic diseases later in adulthood (Williams et al., 2015), such as cardiovascular diseases, diabetes mellitus, certain types of cancer, and consequently, premature mortality and physical morbidity (Williams et al., 2015; World Health Organization, 2022). Therefore, keeping adequate nutrition status with a healthy lifestyle during childhood and adolescence is significant for health-promoting eating habits setup that may prevent the development of nutrition-associated health diseases later in life. In addition, during the time of growing up, it is important to educate children and take all measures to achieve a more sustainable lifestyle and a healthy future. This includes teaching them how to choose a more sustainable diet, with low environmental impacts that contribute to food and nutrition security and healthy life, a diet that is based on plant foods and national dietary guidelines, such as the Mediterranean diet (MD) with reduced intake of meat and industrially processed food. The Mediterranean diet has been added to the UNESCO Intangible Cultural Heritage list in 2010, not only for its nutritional value and proven health impact but also for its cultural and social value, and presented as a model of a sustainable diet beneficial for health and the environment (Trajkovska Petkoska and Trajkovska-Broach, 2021). Furthermore, it is important to educate children to pay attention to reducing food waste, due to its current high levels (Brennan and Browne, 2021), and to adequate food intake that is sufficient for their specific growth and development, which might then prevent overweight and obesity and repercussion like the metabolic complications of obesity such as fatty liver disease, dyslipidemia, diabetes, asthma, sleep apnea and cardiovascular (Sahoo et al., 2015).

Schools are a good setting for health and nutrition promotion programs and education. The World Health Organization (WHO) recommends that schools implement healthy eating habits and strategies that target the school program, environment, and partnerships (World Health Organization; United Nations Educational, 2021). Nutrition education during adolescence has been shown to be effective in increasing knowledge, attitudes, and practices regarding nutrition, due to specific characteristics of adolescence (Sichert-Hellert et al., 2011). Multi-strategy interventions can have significant impacts on adolescents' diet when nutrition education is theoretically based and with the inclusio2 of parents and families (Meiklejohn et al., 2016). There are many nutrition education initiatives with the aim to improve the nutrition knowledge of school children, with the participation of schools, government, and health promotion agencies to prevent or manage dietary-related and lifestyle-related diseases with proven health benefits (O'Brien et al., 2021). The education-based intervention program "Hopscotch—healthy eating" (in Croatian, "Školica—zdrave prehrane") was designed in 2016 to screen and improve nutrition knowledge, diet, and lifestyle of elementary school children. It was conducted until 2020 when it was halted for the COVID-19 lockdown. A multi-component program focused on school children aged 10–12 years because early adolescence represents an important lifetime for implementing nutrition-related and lifestyle-related education that is important for their future habits and health. This program used various forms of education adjusted to school children's education, needs, and perceptions. It is hypothesized that educational programs intended to improve school children's lifestyle and dietary behavior may increase their level of knowledge and positively influence attitudes toward a healthy and sustainable lifestyle, nutrition, dietary behavior, and physical activity. The aim of this study was to evaluate the effect of a nutrition and lifestyle education program on the nutritional knowledge of school children in the fifth-grade elementary schools in the town of Rijeka, Croatia, and to find the association between school children's nutritional knowledge, sociodemographic factors, and lifestyle habits.

2. Methods

2.1. Study design

The study is designed as a pre-test–post-test education-based intervention study, based on guidelines for reporting observational and intervention studies of public health in nutritional epidemiology (Hoffmann et al., 2014). The study as a program was conducted from 2016 to 2020 in all elementary schools in the town of Rijeka, Croatia. Two groups were formed: an intervention group that underwent nutrition and healthy lifestyle education and a control group without education-based intervention. The study data were collected two times: before education (at baseline) and at the end of the education program (for the educated group only), approximately 3 weeks from the baseline. It assessed pre-to-post changes in nutrition knowledge of the fifth-grade school children of elementary schools that were included in the study.

2.2. Participants and recruitment

All elementary schools in the town of Rijeka, Croatia (n = 23) participated in this study, and four elementary schools outside the town of Rijeka were randomly selected for control. All schools received detailed information about education-based intervention, and all selected schools agreed to participate after the study presentation and discussion at teachers' and parents' meetings. The study was anonymous, and no identifying data of the school children were collected at any time, so the parents' consent was not insisted on. However, parents had the opportunity to refuse their child's participation in the study by signing a declaration of non-consent after the study was presented at the meeting. The signed written consent was obtained from school authorities (principals and teachers). The study protocol was explained to the school children verbally as the study began, while the parents received the written information booklet about the study. During 4 years of the study, 3,301 school children attended fifth-grade elementary schools in the town of Rijeka. The inclusion criteria for this study were attending a fifth-grade elementary school in the town of Rijeka, and the questionnaires were completely fulfilled. The exclusion criteria included attending other grades or elementary schools from other cities, as well as incomplete questionnaires. This study included 2,617 school children (79% of all 3,301 fifth-grade school children) who completely participated in all components of the program, from its beginning to the end, i.e., they represent an education-based intervention group (EBIG). Six hundred and ninety-four school children (21% of all fifth-grade school children) were not included in this study, i.e., those who did not participate in all program classes, those who did not fulfill the questionnaire completely, and those whose parents refused their child's participation. This program also included 92 school children attending the fifth grade from three random-chosen elementary schools outside the town of Rijeka, i.e., they represent a control group (CG). The answers of the school children who completely filled out the questionnaire twice within a 3-week span were used for the questionnaire validation. Within the education group of participants (N = 2,617), the monitored subgroup was formed (N = 701), in which the changes in nutrition status, active and sedentary lifestyle, diet quality, and nutrition knowledge were assessed at 6- to 9-month follow-up to measure the medium-term effect of education. The criteria for inclusion into the monitored sub-group were as follows: completely answered a questionnaire from the program filled after 6–9 months of the education-based program of those school children from one-third of classes that were included in the intervention group.

2.3. The education-based intervention program

The program was developed and carried out by academic researchers who were involved in the study. In the intervention group, a nutrition and healthy lifestyle education program was applied that lasted 3 weeks. The program consisted of five interactive presentations on nutrition, sustainability, and lifestyle themes, with guided discussions and activities to identify possible doubts and misunderstandings. It included (1) basic principles of healthy nutrition regarding specific dietary needs for adolescents; (2) the importance of nutrients for health and their food origin; (3) planning a daily menu/meal; (4) the influence of diet on health, and health consequences of unhealthy diet eating disorders; and (5) sustainable eating and living, terminology, culture, sleeping, physical activity, and screen-based media use. Each theme lasted ∼15–20 min and was guided by two–three study researchers. School children had the opportunity to discuss each theme with the researchers and to interact with their peers. The program was performed during weekly class meetings and included the use of brochures, food pictures, healthy lifestyle posters, and a program website specifically developed for this study (http://skolica-prehrane.rijeka.hr/), based on institutional and government recommendations and school-based lessons. Each participant was instructed and encouraged to use the aforementioned program website, which included topics about nutrition, health, physical activity, the human body, eating disorders, sustainable ways of eating and living, and various themes about healthy lifestyle and diet. All themes were specifically developed for children aged 10 years and older as a reader.

2.4. The questionnaire

The questionnaire administration at the beginning of the program was necessary to conduct to evaluate the effect of the implemented education-based intervention program. School children self-administered it anonymously in the classroom in the presence of study researchers and class teachers, after a short introduction and instructions at the very beginning of the program. The questionnaire consisted of four parts: (1) sociodemographic items (age, gender, body weight, and height which were previous to the program baseline measured by their physical education teachers); (2) habits including physical activity (sports and activities during leisure time), sleeping (hours/day), screen time use (TV/PC/tablet/mobile phone); (3) dietary habits; and (4) nutrition knowledge questions. The questionnaire was

administered at the beginning of the study and after 6- to 9-month follow-up. The assessment of the education effect was done after 3 weeks of the baseline analysis for a short-term effect of education in all school children included in the program. The assessment was done with the questionnaire part regarding nutrition knowledge since a 3-week time span might be short for changing dietary and lifestyle habits promoted with the program. A medium-term effect of education was assessed after 6- to 9-month follow-up in one-third of the included school children.

2.4.1. Lifestyle habits

School children noted their physical activities (organized and non-organized), sitting time, screen time use, and sleeping time. They noted the time for doing those activities in offered frequencies as 1–2, 3–4, 5–6 times a week, and every day. They also noted time quantity doing asked activities, offered as less than half an hour, half an hour to 1, 1–2, 3–4, 5–8 h, and more than 8 h.

2.4.2. Dietary habits

The questionnaire part about dietary habits contained questions about the usual frequency and quality of breakfast eating and questions about the frequency and quantities of consuming meals and foods. The frequency was offered from never to less than once a week, 2–3, 4–6 times a week, once a day, and two or more times a day. The participants noted their usual intake of consumed meals and food offered as smaller than the serving, a serving, and larger than the serving. By using the Croatian food composition database (Kaić-Rak and Antonić, 1990), the school children's diet quality was calculated and then evaluated with the Mediterranean Diet Quality Index for children and adolescents (KIDMED) to estimate the adherence to the Mediterranean diet (MD) (García Cabrera et al., 2015). This score was chosen because the town of Rijeka is in the littoral part of Croatia, where the Mediterranean diet is considered an inherited diet (Keys, 1997), and MD is considered a model for a sustainable diet (Trajkovska Petkoska and Trajkovska-Broach, 2021). The overall KIDMED score ranged from 0 to 12. A value of +1 was assigned for the consumption of fruits, vegetables, legumes, wholegrain cereals, nuts, milk and dairy products, yogurt, and olive oil due to their positive characteristics relating to MD, and a value of −1 was assigned for the consumption of baked goods, sweets and desserts, fast food, and skipping breakfast due to a negative aspect. According to the summed KIDMED overall score, adherence to MD was divided into three levels: low adherence (≤3 points), medium adherence (4–7 points), and high adherence to MD (≥8 points).

2.4.3. Nutrition knowledge

The questionnaire part about nutrition knowledge (NK) had 12 questions based on themes from nutrition lessons in the elementary school's nature and biology curriculum. Questions were previously reviewed for content validity and appropriateness for fifth-grade elementary school children by health educators, elementary school teachers, and dieticians. The reviewing criteria were the relevance to the content area, level of difficulty, and appropriateness for the study participants. Each question had four response categories, including "I don't know." The overall NK score of each study participant was calculated by summing the points from correct answers to each question, which was scored as 1 point. Based on the overall NK score, participants were further distributed a priori into three levels of NK: low NK (≤5 points), moderate NK (6–7 points), and high NK (≥8 points).

2.5. Statistical analysis

Categorical variables are presented as number (N) and percentage (%), and continuous variables are presented as means and 95% confidence intervals. The normality of variable distribution was verified with the Kolmogorov–Smirnov test before the statistical analysis. The differences regarding nutrition-level groups were tested with a chi-square test for categorical variables and an ANOVA test for continuous variables. The changes in nutrition knowledge score after a 3-week follow-up regarding the baseline were tested with a paired *t*-test. Logistic regression was applied to assess the chance for adequate nutrition knowledge, nutritive status, active and sedentary lifestyle, and diet quality in relation to the control group as a reference for results from the study baseline. The odds ratios (ORs) and 95% CIs were calculated after the adjustments for gender, nutrition status, screen time and physical activity (hours), eating breakfast, and KIDMED score (points) as confounders. Evaluation of baseline and 6- to 9-month follow-up changes in the scores of nutrition knowledge questionnaire items for the monitored sub-group of the education-based intervention group were conducted using the paired sample *t*-test and the McNemar test. All changes were calculated using a z-score [(mean at the follow-up – baseline mean)/baseline mean × 100]. The reliability of the nutrition knowledge questionnaire was assessed with Pearson's correlation coefficients for knowledge scores at the mentioned two-time points. For this study, correlations below 0.49 were considered weak, correlations between 0.50 and 0.59 were considered moderate, and correlations between 0.60 and 1.00 were considered high (Eterović and Kardum, 2010). The results of test–retest comparison of nutrition knowledge scores between school children of the EBIG group and the CG group were used to evaluate the validity of this school-based intervention program. All tests were two-tailed, and a *p*-value of <0.05 was considered significant. All analyses were performed using Statistica software for Windows, version 12.7 (StatSoft Inc., Tulsa, OK, USA).

3. Results

This study included 2,709 school children who attended fifth-grade elementary schools [1,351 boys (49.9%) and 1,358 girls (50.1%)]; 2,617 were from the town of Rijeka [education-based intervention group (EBIG)] and 92 were from outside of the town of Rijeka [control group (CG)]. Their mean age was 11.04 ± 0.42 years, and their mean body mass index was 18.52 ± 3.98 kg/m^2. Table 1 shows school children's characteristics, lifestyle habits, diet quality, and nutrition knowledge at the baseline and the follow-up distributed to their baseline nutrition knowledge level. In the EBIG group, boys and girls were distributed almost equally [1,320 (50.4%)

TABLE 1 The characteristics, lifestyle habits and nutrition knowledge of 2,709 school children according to the baseline nutrition knowledge level [*N* (%) or mean (95% confidence interval)]*.

Variables	Education-based intervention group, EBIG	Control group, CG	Education-based intervention group, EBIG				Control group, CG			
			Nutrition knowledge level				Nutrition knowledge level			
	N (%)	*N* (%)	Low (≤5 points)	Medium (6–7 points)	High (≥8 points)	*P*-value[a,b]	Low (≤5 points)	Medium (6–7 points)	High (≥8 points)	*P*-value[a,b]
Total	2,617 (100.0)	92 (100.0)	318 (12.2)	1,593 (60.9)	706 (26.9)	<0.001	39 (42.4)	27 (29.3)	26 (28.3)	0.134
Boys	1,320 (50.4)	31 (33.7)	188 (59.1)	793 (49.8)	339 (48.0)	<0.001	10 (25.6)	15 (55.6)	6 (23.1)	0.217
Girls	1,297 (49.6)	61 (66.3)	130 (40.9)	800 (50.2)	367 (52.0)	<0.001	29 (74.4)	12 (44.4)	20 (76.9)	0.044
BMI (kg/m^2)*	18.52 (18.37, 18.67)	18.39 (17.55, 19.23)	18.56 (18.13, 18.99)	18.67 (18.47, 18.87)	18.18 (17.90, 18.47)	0.024	22.24 (19.73, 24.75)	20.58 (17.97, 23.19)	17.57 (16.61, 18.54)	0.131
BMI-for-age level (categories)										
Underweight	275 (10.5)	19 (20.7)	38 (11.9)	157 (9.9)	80 (11.3)	<0.001	14 (35.9)	3 (11.1)	2 (7.7)	0.004
Normal weight	1,789 (68.4)	43 (46.7)	219 (68.9)	1,077 (67.6)	493 (69.8)	<0.001	4 (10.3)	15 (55.6)	24 (92.3)	0.002
Overweight	324 (12.4)	8 (8.7)	39 (12.3)	208 (13.0)	77 (10.9)	<0.001	0 (0.0)	8 (29.6)	0 (0.0)	0.001
Obese	229 (8.8)	22 (23.9)	22 (6.9)	151 (9.5)	56 (7.9)	<0.001	21 (53.8)	1 (3.7)	0 (0.0)	<0.001
TV watching (h/day)*	1.58 (1.53, 1.63)	1.73 (1.26, 2.20)	1.70 (1.52, 1.88)	1.59 (1.53, 1.65)	1.52 (1.44, 1.50)	0.099	1.40 (1.19, 1.61)	2.15 (1.00, 3.30)	1.23 (0.80, 1.66)	0.359
PC/tablet/mobile phone use (h/day)*	1.66 (1.60, 1.72)	1.35 (1.14, 1.57)	2.07 (1.88, 2.26)	1.67 (1.60, 1.74)	1.44 (1.35, 1.53)	<0.001	1.05 (0.90, 1.20)	1.15 (0.69, 1.61)	1.53 (1.17, 1.89)	0.294
Sleep (h/day)*	8.93 (8.93, 8.93)	8.12 (7.93, 8.31)	8.82 (8.70, 8.94)	8.93 (8.89, 8.97)	8.97 (8.91, 9.03)	0.075	8.00 (7.76, 8.24)	8.25 (7.92, 8.58)	8.00 (7.60, 8.40)	0.673
Organized sports users	2,024 (77.3)	66 (71.7)	195 (62.3)	1,239 (77.8)	590 (83.6)	<0.001	27 (40.9)	15 (22.7)	24 (36.4)	0.170

(Continued)

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TABLE 1 (Continued)

Variables	Education-based intervention group, EBIG	Control group, CG	Education-based intervention group, EBIG				Control group, CG			
			Nutrition knowledge level				Nutrition knowledge level			
	N (%)	*N* (%)	Low (≤5 points)	Medium (6–7 points)	High (≥8 points)	*P*-value[a,b]	Low (≤5 points)	Medium (6–7 points)	High (≥8 points)	*P*-value[a,b]
Not eating breakfast	418 (15.9)	14 (15.2)	82 (25.8)	267 (16.8)	69 (16.5)	<0.001	10 (71.4)	0 (0.0)	4 (28.6)	0.010
KIDMED score (points)*	6.77 (6.69, 6.85)	6.99 (6.60, 7.38)	5.80 (5.56, 6.04)	6.76 (6.66, 6.87)	7.24 (7.09, 7.39)	<0.001	6.00 (5.37, 6.63)	7.93 (7.15, 8.71)	8.23 (7.62, 8.84)	0.003
KIDMED score (categories)										
Low	182 (7.0)	6 (6.5)	46 (14.5)	106 (6.7)	30 (4.2)	<0.001	6 (15.4)	0 (0.0)	0 (0.0)	0.002
Moderate	1,429 (54.6)	41 (44.6)	205 (64.5)	886 (55.6)	338 (47.9)	<0.001	21 (53.8)	10 (37.0)	10 (38.5)	0.069
High	1,006 (38.4)	45 (48.9)	67 (21.0)	601 (37.7)	338 (47.9)	<0.001	12 (30.8)	17 (63.0)	16 (61.5)	0.627
Baseline nutrition knowledge score (points)*										
	6.38 (6.69, 6.85)	7.03 (6.71, 7.35)	3.26 (3.14, 3.38)	6.14 (6.10, 6.18)	8.33 (8.29, 8.37)	<0.001	4.55 (4.29, 4.84)	6.43 (6.24, 6.62)	8.38 (8.13, 8.36)	<0.001
Follow-up nutrition knowledge score (points)*										
	11.20 (11.17, 11.23)	8.83 (8.49, 9.17)	11.12 (11.02, 11.22)	11.21 (11.17, 11.25)	11.28 (11.22, 11.34)	0.013	6.00 (5.51, 6.49)	7.36 (7.08, 7.64)	9.15 (8.80, 9.50)	<0.001

*Values presented as means (±95% confidence interval).

[a]Chi-squared test for categorical variables between nutrition level groups ($p < 0.05$); [b]ANOVA test for continuous variables between nutrition level groups ($p < 0.05$).

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boys, 1,297 (49.6%) girls], but there were twice as many girls in the CG group [31 (33.7%) boys, 61 (66.3%) girls]. In the EBIG group, most of the children were significantly distributed in the medium (60.9%) and high (26.9%) NK level group ($p < 0.001$), while in the CG group, children were almost equally distributed in each NK level group, with the majority in the low NK group (Table 1). In the EBIG group, boys were significantly more distributed in the low NK group and girls were significantly more distributed in the medium and high NK groups (all $p < 0.001$), while in the CG group, boys were more distributed in the low and medium groups and girls were significantly more distributed in the low and high NK groups ($p = 0.044$). Significantly, the lowest BMI value was in the high NK group in both study groups ($p = 0.024$, $p = 0.131$, respectively, Table 1). Regarding BMI-for-age groups, significantly more EBIG group children were underweight in the low NK group ($p < 0.001$), normal weight children were significantly more in the high NK group ($p < 0.001$), and those with overweight and obesity were significantly more in the low NK group (both $p < 0.001$), with a similar distribution in the CG group (Table 1). The average hours of weekly watching TV and daily sleep did not differ regarding the NK level group in both study groups. The average hours spent using media-based screens were significantly higher in the low NK group in the EBIG group ($p < 0.001$), while in the CG group, children spent more hours than in the medium and high NK groups (Table 1). In the EBIG, the low NK subgroup had significantly more children who did not eat breakfast ($p < 0.001$) and had the least children who participated in weekly organized sports ($p < 0.001$). Not eating breakfast ($p = 0.010$) was similar to the CG group, while going to organized sports did not differ regarding NK level ($p = 0.170$). The average KIDMED index of the EBIG group was 6.77 ± 2.15 points and of the CG group was 7.90 ± 1.90, meaning that the average diet of both studied groups adhered moderately to the Mediterranean diet (Table 1). In both study groups, there were significantly more children with low adherence to the MD distributed in the low NK level group ($p < 0.001$, $p = 0.002$, respectively) and more children with high adherence to MD distributed in the medium and high NK level groups but significantly in the EBIG group ($p < 0.001$) than in the CG group ($p = 0.627$). In the EBIG group, the average baseline NK score significantly increased from an average of 6.38 points to an average follow-up of 11.20 points (+75.5%, $p < 0.001$). In the CG group, the average NK score significantly increased from an average of 7.03–8.83 points (+25.6%, $p = 0.040$).

The chances for better nutrition knowledge, nutritive status, active and sedentary lifestyle, and diet quality in relation to the control group as a reference for study baseline results are shown in Table 2. The chance for nutrition knowledge above the median of 7 was lower for 77% in the EBIG group compared with the CG group but not significantly ($p = 0.106$), and after the education program, that chance increased significantly by 14% compared with the CG group ($p = 0.027$) (data not shown). The chance of having better nutrition knowledge and going to organized sports was almost two times higher in the EBIG group than in the CG group ($p = 0.024$). The chance of using a few hours for screen-based media was significantly lower for 36% in the EBIG group in comparison to the CG group ($p < 0.001$). The chance of watching TV <2 h/day was almost similar (OR = 1.04, $p = 0.422$), while regular breakfast eating was higher but not significant in the EBIG group compared with the CG group (OR = 1.20, $p = 0.269$). The chance of better adherence to nutrition knowledge and being underweight was 93% lower in the CG group but not significant ($p = 0.438$). In the EBIG group compared with the control, the chance of overweight/obesity was higher at 49% but not significantly ($p = 0.154$). The control group had higher chances for moderate (26%, $p < 0.001$) and high adherence to MD (17%, $p < 0.001$) than the EBIG group.

In this study, the impact of the education-based intervention program was assessed by noting the changes recorded 6–9 months after the program was held. The changes in nutrition status, active and sedentary lifestyle, and diet quality were assessed in the monitored sub-group ($N = 701$) and are presented in Figure 1. The same changes are also presented regarding their baseline nutrition knowledge level (Table 3). The BMI value did not significantly change at the time of the follow-up (18.70–18.91 kg/m^2; $p = 0.762$), but there was a significant change in categories of BMI-for-age level (Figure 1). The underweight and obesity groups significantly halved their proportions (−56.6 and −57.5%, respectively, all $p < 0.001$). The normal weight group significantly raised its proportion by a quarter (24.8%, $p < 0.001$), and the overweight group decreased it by a fifth (−22.1%, $p < 0.001$). Sleeping hours did not significantly change (−4.4%, $p = 0.057$), but children significantly decreased the time for watching TV for a quarter (−25.3%, $p < 0.001$) and increased using PC/tablet/mobile phone use for a third (29.5, $p > 0.001$) (data not shown). Compared with the baseline, there were significantly few children who declared not eating breakfast at the follow-up, for one-seventh less (−14.0%, $p < 0.001$) and one-seventh more children as organized sports users (13.2%, $p < 0.001$) (Figure 1). Children's KIDMED scores significantly increased by 15.3% ($p < 0.001$), and the proportion of children with a baseline diet that low and moderately adhered to the MD significantly decreased at the follow-up (−62.5 and −62.3%, respectively, all $p < 0.001$) (Figure 1). Concurrently, the proportion of children whose diet highly adhered to the MD significantly doubled (+105.0%, $p < 0.001$). The NK knowledge score assessed at the 6- to 9-month follow-up increased significantly for two-thirds from the baseline (6.33–10.56, $p < 0.001$), and there was a significant decrease in the proportion of the low and medium NK level groups at the baseline (−80.5 and −55.9%, respectively, all $p < 0.001$) (Table 3). The proportion of children in the high NK level group at the baseline significantly increased by 174.3% ($p < 0.001$) (Table 3). Regarding the highest level of NK, there was a significant increase in the proportion of children with normal weight (+218.9%, $p < 0.001$), who were organized sports users (+204.7%, $p = 0.005$), not eating breakfast (+246.7%, $p < 0.001$), and with a highly adherent diet to the MD (+291.8%, $p < 0.001$) (Table 3).

This study evaluated the reliability of the education-based intervention program questionnaire by comparing baseline nutrition knowledge questions with the same questions at the follow-up (Table 4). In the EBIG group, there was a significant increase in the knowledge of daily servings of fruits and vegetables (+49.1%, $p < 0.001$), a healthy meal (+24.1%, $p < 0.001$) and food (+37.0%, $p < 0.001$), a food source of vitamin C (+32.0%, $p = 0.003$), calcium (+24.8%, $p < 0.001$), and

TABLE 2 The adjusted odds ratios (95% CI) for nutrition knowledge, gender, nutrition status, active and sedentary lifestyle, and diet quality in the intervention group in the relation to the control group as referent at the study baseline.

Variable		Education-based intervention group		
		Adjusted OR	95% CI range	*P*-value
Nutrition knowledge score	<Median	1		
	≥Median	0.77	0.50–1.17	0.106
Gender	Boys	1		
	Girls	0.43	0.24–0.78	0.003
Nutrition status	Underweight	1		
	Normal weight	0.80	0.43–1.49	0.238
	Overweight	1.48	0.58–3.76	0.205
	Obese	0.72	0.30–1.73	0.235
Organized sports	No	1		
	Yes	1.61	1.00–2.60	0.024
TV watching	≥2 h/day	1		
	<2 h/day	1.04	0.68–1.61	0.422
PC/tablet/mobile phone use	≥2 h/day	1		
	<2 h/day	0.36	0.21–0.62	<0.001
Breakfast (every day and few times/week)	No	1		
	Yes	1.20	0.67–2.18	0.269
KIDMED tertiles	Low	1		
	Moderate	0.26	0.13–0.50	<0.001
	High	0.17	0.08–0.36	<0.001

Adjustments were done for gender, nutrition status, screen time and physical activity (hours), eating breakfast and KIDMED score.

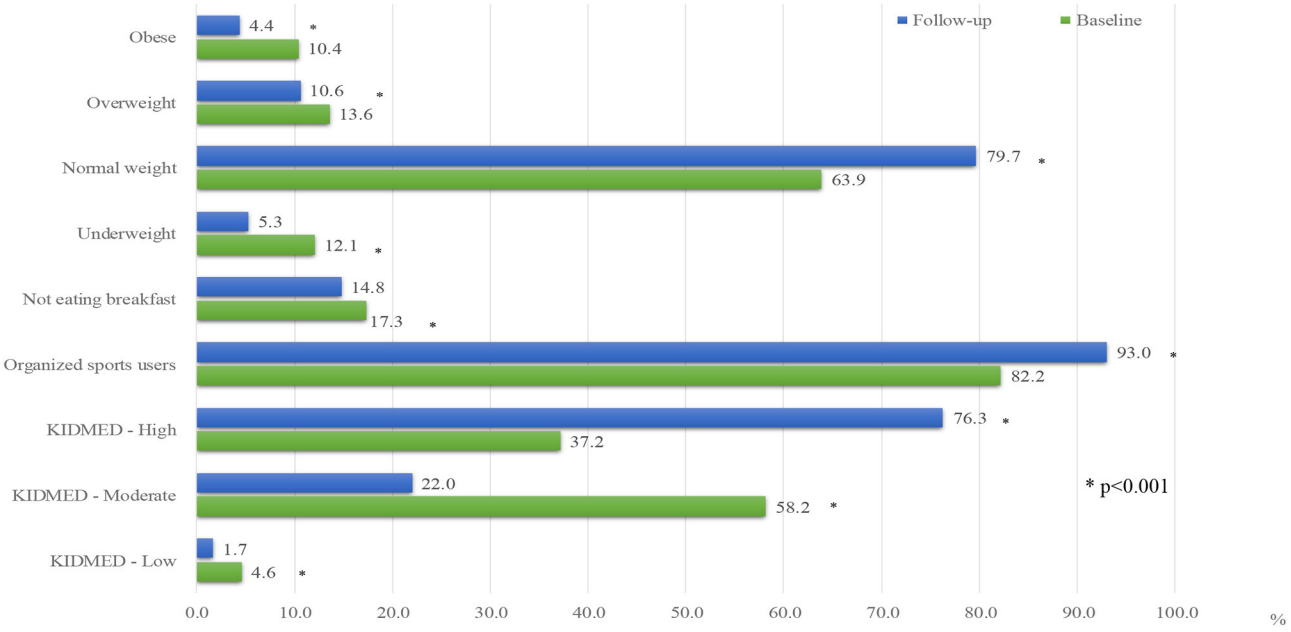

FIGURE 1
Changes in nutrition status, active and sedentary lifestyle, and diet quality of monitored sub-group ($N = 701$) within education-based intervention group ($N = 2{,}617$) from the baseline to the 6–9-month follow-up.

TABLE 3 Changes in nutrition status, active and sedentary lifestyle, and diet quality regarding nutrition knowledge level of monitored sub-group ($N = 701$) within education-based intervention group ($N = 2,617$) from the baseline to the 6–9-month follow-up.

Variables	Nutrition knowledge level								
	Low			Medium			High		
	Baseline ($n = 87$)	Follow-up ($n = 17$)	*p*-value[a]	Baseline ($n = 435$)	Follow-up ($n = 192$)	*p*-value[a]	Baseline ($n = 179$)	Follow-up ($n = 492$)	*p*-value[a]
BMI-for-age level (categories)									
Underweight	10 (11.5)	0 (0.0)	<0.001	58 (13.3)	8 (4.2)	<0.001	17 (9.5)	29 (5.9)	<0.001
Normal weight	59 (67.8)	14 (82.4)	0.031	267 (61.3)	156 (81.3)	0.505	122 (68.1)	389 (79.1)	<0.001
Overweight	10 (11.5)	1 (5.9)	<0.001	62 (14.3)	20 (10.3)	<0.001	23 (12.9)	54 (10.9)	<0.001
Obese	8 (9.2)	2 (11.7)	<0.001	48 (11.1)	8 (4.2)	<0.001	17 (9.5)	20 (4.1)	<0.001
Organized sports users	71 (81.6)	17 (100.0)	<0.001	356 (81.8)	131 (68.2)	<0.001	149 (83.2)	454 (92.3)	0.005
Not eating breakfast	15 (17.2)	3 (17.6)	<0.001	76 (17.5)	37 (19.3)	<0.001	30 (16.8)	104 (21.1)	<0.001
KIDMED score (categories)									
Low	2 (2.3)	1 (5.9)	<0.001	4 (3.7)	7 (2.1)	<0.001	14 (7.8)	7 (1.4)	<0.001
Moderate	36 (41.4)	5 (29.4)	<0.001	44 (36.1)	105 (22.9)	<0.001	68 (38.0)	105 (21.3)	0.683
High	46 (56.3)	11 (64.7)	<0.001	144 (60.2)	380 (75.0)	0.103	97 (54.2)	380 (77.2)	<0.001

[a]McNemar test for repeated categorical variables ($p < 0.05$).

proteins (+14.3%, $p < 0.001$). After the education program, children had significantly higher knowledge about high-energy nutrients, recommendations for fluid intake (+4.0%, $p = 0.021$), and physical activity (+6.9%, $p = 0.007$). In the CG group, a significant increase was noted in knowledge about daily servings of fruits and vegetables (+31.1%, $p = 0.023$) and healthy food (+38.0%, $p = 0.003$). In the EBIG group, test–retest correlations that were above 0.60 showed good reliability for all NK questions except for questions related to the food sources of vitamin C and calcium, which showed marginal moderate correlations ($r = 0.59$, $p = 0.001$; $r = 0.51$, $p < 0.001$, respectively) (Table 4). In the CG group, high reliability was found for knowledge about healthy meals ($r = 0.97$, $p < 0.001$), unhealthy food ($r = 0.97$, $p < 0.001$), and fluid intake ($r = 0.69$, $p = 0.002$), and moderate for other NK questions.

4. Discussion

This study evaluated the effect of an education-based intervention program promoting a healthy and sustainable diet and lifestyle that included almost 80% of all fifth-grade school children who attended elementary schools in the town of Rijeka from 2016 to 2020. With the implementation of this program, school children achieved a significant increase in their nutrition knowledge, three-fourths expressed as a short-term effect of the education-based intervention program, and it was maintained, as shown at the 6- to 9-month follow-up, presenting a significant medium-term effect of the education-based intervention program. The obtained results of the study are consistent with the results of similar education-based intervention studies among school children in elementary schools that aimed to improve nutrition knowledge, diet quality, nutrition status, and lifestyle behavior (El Harake et al., 2018; Wadolowska et al., 2019; Antwi et al., 2020; Charles Shapu et al., 2020; Annan et al., 2021; Shen et al., 2021; Thakur and Mathur, 2021; Oddo et al., 2022).

An increase in the NK score was also observed in the control group, which was a quarter higher than the baseline score. Although the control group was selected outside the area of elementary schools involved in the program to exclude cross-communication, it is possible that children from the control group discussed among themselves about the questionnaires and searched for correct answers, so the follow-up results are better. The lower chances for better nutrition knowledge had children participating in the education group, but their nutrition knowledge significantly increased after the educational program. The interventional group scored three times higher at the short-term follow-up NK and maintained it at the 6- to 9-month follow-up, which highlights the significant effect of the intervention education program. The greatest improvement was in knowledge about daily servings of fruits and vegetables, a healthy meal and food components and serving size, and better recognition of food sources of nutrients. Fruits and vegetables abound with micronutrients, fiber, and beneficial bioactive compounds (Liu, 2013). High intake of fruits and vegetables among European adolescents was associated with increased blood vitamin concentrations (Mielgo-Ayuso et al.,

TABLE 4 Comparison of nutrition knowledge between education-based intervention group and control group and test–retest comparison of nutrition knowledge scores for the reliability of nutrition knowledge questionnaire.

Nutrition knowledge questionnaire item	Education-based intervention group ($N = 2,617$)					Control group ($N = 92$)				
	Baseline	Follow-up				Initial test	Retest			
	Correct answers (%)	Correct answers (%)	McNemar test p-value	Spearman's correlation coefficient	Repeated t-test p-value	Correct answers (%)	Correct answers (%)	McNemar test p-value	Spearman's correlation coefficient	Repeated t-test p-value
Daily servings of fruits and vegetables	21.6	70.7	0.001	0.74	<0.001	44.8	75.9	0.093	0.46	0.005
Healthy breakfast	91.0	90.8	<0.001	0.73	0.266	100.0	100.0	<0.001	1.00	1.000
Healthy meal	52.9	77.1	<0.001	0.68	<0.001	100.0	96.6	<0.001	0.97	<0.001
Healthy food	49.5	86.5	<0.001	0.88	<0.001	10.3	48.3	<0.001	0.41	0.001
Unhealthy food	72.6	88.6	<0.001	0.70	0.186	100.0	96.6	<0.001	0.97	<0.001
A good source of vitamin C	31.4	63.4	0.021	0.59	0.001	79.3	86.2	<0.001	0.49	0.002
A good source of energy	37.1	73.3	<0.001	0.81	0.419	10.3	27.6	<0.001	0.55	0.011
A good source of calcium	45.8	70.6	<0.001	0.51	<0.001	79.3	69.0	<0.001	0.41	0.001
A good source of proteins	65.0	79.3	<0.001	0.65	<0.001	72.4	79.3	<0.001	0.47	0.002
High energy nutrients	9.2	29.0	<0.001	0.69	<0.001	10.3	31.0	<0.001	0.56	0.016
Fluid intake	86.5	90.5	<0.001	0.64	0.008	100.0	96.6	<0.001	0.69	0.002
Physical activity recommendations	65.8	72.7	<0.001	0.63	0.003	75.9	75.9	<0.001	0.46	0.004

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2017a). However, low fruit and vegetable intake has been shown to be a major contributor to the global burden of disease, particularly non-communicable diseases (Lim et al., 2012). Sahingoz and Sanlier have reported that poor nutrition knowledge of Turkish adolescents was associated with low adherence to the MD, specifically that related to food sources of macronutrients and micronutrients (Sahingoz and Sanlier, 2011). A nutrition education program conducted among 85 Italian adolescents showed not only improvement in their diet toward better adherence to MD after a 6-month follow-up, but also improvement in inflammatory status, after participating in two nutrition education sessions and an MD personalized plan (Morelli et al., 2021).

This study showed that even at the study baseline, there were statistically more children who scored better for NK and whose diet adhered to MD, as well as significant improvement in diet quality toward better adherence to MD at the 6- to 9-month follow-up. These results are important because a recent Italian study among 2,869 adults showed that a healthy dietary pattern such as the Mediterranean diet is closely linked to the literacy of the population in terms of better nutrition knowledge (Aureli and Rossi, 2022), which confirms the necessity for early nutrition education with the aim to be maintained in adulthood and consequent influence on better health. This is important since there is established distancing from inherited MD that has undesirable effects not only on health but also on social, cultural, economic, and environmental trends in the Mediterranean region (International Centre for Advanced Mediterranean Agronomic Studies/Food Agriculture Organization of the United Nations, 2015). In Croatia, a distancing was also observed from the MD in young adults (Kolčić et al., 2016; Pavičić ŽeŽelj et al., 2018) and among older students (Matana et al., 2022). In fact, this study revealed a higher proportion of school children with medium to high adherence to MD than a recent Croatian study among school children of similar age as this study (Matana et al., 2022). Although Matana et al. involved children and youths from the Mediterranean region of Croatia, they revealed important results valuable for Croatian future programs and projects, but they did not show the distribution of participants by the regions of the Mediterranean part of Croatia (e.g., North vs. South). It would be interesting to compare those results with the results of this study, which included school children from the town of Rijeka, where the MD is a heritage diet that has been promoted in kindergartens and schools through local health programs for almost 40 years. Actually, a recent study on the online-learning influence on the nutrition and lifestyle of school children in Primorsko-Goranska County during the COVID-19 lockdown (Kendel Jovanović et al., 2021) also showed a high proportion of school children with a diet that adhered to MD. Those results are probably because their parents not only accepted messages of nutritional recommendations promoting MD during the COVID-19 lockdown but also promoted active long-term MD with health programs in kindergartens and schools in Primorsko-Goranska County in Croatia, one of which is the presented education-based intervention program "Hopscotch—healthy eating" started from 2016. Although Matana et al. (2022) used the same KIDMED questionnaire, they gathered results from an online survey, whereas this study used results from paper questionnaires, which were filled out with the assistance of nutritionists, which may explain a higher proportion of children whose diet adhered to MD. Skipping breakfast by children and adolescents has been shown to be a risk factor for obesity (Ardeshirlarijani et al., 2019) and metabolic diseases, and to be associated with a worse lipid profile, blood pressure levels, and insulin resistance (Monzani et al., 2019). This education-based intervention program showed a slightly larger proportion of children not eating breakfast than it was among children of the same age recently assessed in the Mediterranean regions of Croatia (Matana et al., 2022), whose survey was conducted during the COVID-19 lockdown measures when children stayed at home more, which gave them the opportunity for more regular breakfast eating. However, this study also found a significant increase in regular breakfast eater's proportion which could be recognized as a medium-term education effect. A multinational cross-sectional study HELENA found that breakfast consumption was linked to better dietary quality scores than children who usually skip breakfast (Giménez-Legarre et al., 2022), and found that regular breakfast eating is associated with better blood vitamin concentrations in European adolescents (Mielgo-Ayuso et al., 2017b). This could be beneficial for children who participated in this education program since it has influenced the increase in regular breakfast eating. The WHO recently reported that 60% of European area citizens are either overweight or obese, highlighting the implications of the obesity pandemic, especially being complicated by the COVID-19 pandemic, creating a twin pandemic, and consequently increased morbidity and mortality (Boutari and Mantzoros, 2022). It is predicted that across the European region, 11.13% of adolescents aged 10–19 years will be affected by obesity by 2030 (Lobstein et al., 2022), and in Croatia, the highest prevalence rate would be 19%. At the 6- to 9-month follow-up, this educational program showed a significant decrease in the prevalence of overweight and obesity among monitored children who maintained their average NK score almost the same (11.16 at the end of the program and 10.56 at the 6- to 9-month follow-up). A recent systematic review assessed 50 healthy and sustainable dietary patterns in children and adolescents by measuring adherence to healthy and/or sustainable dietary patterns, with the Mediterranean diet as the most studied dietary pattern. The review found that higher adherence to the reviewed sustainable dietary patterns was associated with lower body fat, waist circumference, blood pressure, and metabolic risk, but there was no consensus regarding the association with BMI (Teixeira et al., 2022) and concluded that there is a need for a new sustainable instrument or test in association with, e.g., the ecological and water footprints since no studies provide evidence of the sustainability. Recently, a 30-item Sustainable-Healthy-Diet (SHED) Index score was developed for measuring healthy and sustainable individual diets and reflecting the nutritional, environmental, and sociocultural aspects of sustainable diets (Tepper et al., 2021) that found a significant correlation between the SHED index score and the Mediterranean diet score, confirming the MD as a sustainable diet. Nevertheless, all those facts and this study's results accent the necessity and beneficial effects of nutritional educational programs based on the promotion of the Mediterranean diet, that is, aimed at school children and in the

prevention of obesity. Sedentary lifestyle habits are associated with a higher risk of obesity and cardio-metabolic disease both in adults and children (Wu et al., 2017). In contrast, physical activity is known for its associated health benefits for adolescents, such as cardio-metabolic properties, motor skill development, bone density, psychological health, and emotional regulation (Janssen and Leblanc, 2010). This study showed that significantly more children with greater nutrition knowledge are also organized sports users and have a diet that highly adheres to MD implying that the significant increase in organized sports users among the monitored group could be a possible medium-term effect of this educational program. All these positive effects of the educational program may be considered a potential benefit of healthy lifestyle habits for good health in adulthood. The study results are similar to other studies showing a positive association between physical activity and other healthy lifestyle habits, including appropriate nutrition and MD adherence (Iaccarino Idelson et al., 2017; Matana et al., 2022). This study assessed the validity and reproducibility of the used nutrition knowledge questionnaire. For the total and almost all questionnaire components' scores, the strength of Spearman's correlation between the test at the baseline and retest at the follow-up was good and moderate, demonstrating the used questionnaire as a good and reliable tool for use in nutritional education programs.

The strength of this study relies on presenting a significant medium-term effect of the educational program on improving not only school children's nutrition knowledge but also a healthy lifestyle by having a diet that adhered to the MD, more engagement in sports, and improvements in nutritional status. An additional strength of this study is that it represents the first Croatian study, to the authors' knowledge, that presented the results of the educational nutrition and lifestyle program based on the Mediterranean diet and involved four-fifth of all fifth-grade school children of the town of Rijeka. In addition to promoting a healthy diet and physical activity as a basis for a healthy lifestyle, this educational program promoted an understanding of sustainability as a foundation for future healthy living. Because sustainable diets are those diets with low environmental impacts that contribute to food and nutrition security and to healthy life for present and future generations (Burlingame and Dernini, 2012), it was necessary to implement this into the educational program and to discuss it with children. Within this educational nutrition and lifestyle program, children discussed how to choose a plant-based diet such as the MD with a low intake of ultra-processed foods, shopping for locally produced foods, and understanding labels on food products, and the meaning of "sustainability," "carbon footprint," and "emission." It was discussed to accept a nutritional sustainable diet such as the MD and to understand the difference between a sustainable diet and sustainable food systems. The effect of this part of the educational nutrition and lifestyle program was not assessed since the main objective of the program was to promote a healthy diet and lifestyle among school children by improving their nutrition knowledge. This could be considered a potential study limitation. The design of this educational nutrition and lifestyle program avoided potential limitations of cross-communication of nutritional knowledge between the education-based group and control group. The fulfillment of the questionnaires assisted by nutritionists was used to prevent a potential bias regarding self-reporting of study variables, such as dietary, physical activity, screen-based media usage, and sleeping habits. Additional study strength is that.

5. Conclusion

This study showed a significantly good medium-term effect of education-based nutrition and lifestyle intervention program by improvements in nutrition knowledge, diet quality, lifestyle, and nutritional status of Rijeka's school children aged 10–12 years. The presented public health program promoted a Mediterranean diet and lifestyle as a healthy and sustainable way of living, important for children's future health and wellbeing. Promoting sustainable dietary patterns and understanding factors of living healthy and sustainability is a challenge for 2020s public health nutrition policies and it is crucial for the future wellbeing of the whole planet. Sustainability should be promoted with public health programs, food and nutrition messages, and policies, especially for children. The consequences of unhealthy dietary and lifestyle behaviors are of concern not only for health but also for social, economic, and environmental areas. Children should be more involved in health and sustainability promotion education programs. Making children more aware and capable of handling sustainable living complexity needs new research-based approaches.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving human participants were reviewed and approved by the Ethic Committee of the Teaching Institute of Primorsko-Goranska County. Written informed consent from the participants' legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

Conceptualization, analysis, and drafting: GK. Methodology: GK and SP. Sampling: GK and SJ. Research: GK, SP, and SJ. Editing the review and supervision: SP. All authors have read and agreed to the publication of this manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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