

Impact of a Nutrition Education Intervention on Adherence to the Mediterranean Diet among Moroccan Adolescents

Ghizlane Benaddi*, Halima Daif*, Soukaina Ben Angua*, Anouar Rafik*, Omar El Hiba*, Rekia Belahsen* **

*Laboratory of Anthropogenetic, Biotechnologies and Health, Research Unit on Nutrition & Food Sciences, Department of Biology, Faculty of Sciences, Chouaib Doukkali University, El Jadida, Morocco

**rekiabelahsen@gmail.com (Corresponding author)

Abstract: Promoting sustainable dietary choices is a public health priority. This study aimed to evaluate the impact of a nutrition education intervention using the KIDMED index among Moroccan adolescents. A before-and-after intervention study was conducted among adolescents aged 14–18 years. Sociodemographic, socioeconomic, anthropometric and dietary data were collected at baseline and adherence to the Mediterranean diet was assessed before and after the intervention using the KIDMED index. Gender differences were observed for some anthropometric parameters, with more pronounced central adiposity in girls. The mean KIDMED score increased significantly after the educational intervention ($p < 0.001$).

Conclusion: This study suggests that nutrition education can improve adherence to the Mediterranean diet among Moroccan adolescents, even in a socioeconomically disadvantaged context. These findings support the development of locally adapted nutrition education programmes.

Keywords: Mediterranean diet, KIDMED, Nutrition education intervention, Moroccan adolescents.

Introduction

The Mediterranean diet has been the subject of sustained scientific interest since the seminal work of Ancel Keys in the 1950s. Through the Seven Countries Study, Keys and his colleagues demonstrated lower overall and

cardiovascular mortality, and higher life expectancy, in the countries of the Mediterranean basin compared to other regions of the world (Keys, 1995). Since then, this dietary pattern has been considered one of the diets with the highest level of scientific evidence regarding its health benefits, particularly in the prevention of cardiovascular disease, type 2 diabetes, and certain chronic conditions (Serra-Majem et al., 2019). Recognising its sustainable benefits on health the Mediterranean diet was claimed as sustainable diet by FAO (FAO, 2010 ; Serra-Majem et al., 2022). In 2010, the Mediterranean diet was inscribed on UNESCO's Representative List of the Intangible Cultural Heritage of Humanity, acknowledging its cultural significance, traditional knowledge and social practices related to food and lifestyle (UNESCO, 2010). However, while the benefits of the Mediterranean diet are well-documented, the majority of robust evidence comes from studies conducted on adults. Data on interventions in adolescents, on the other hand, remain comparatively more limited and sometimes less consistent, particularly regarding short-term effects on weight.

At the same time, the rise in overweight and obesity among children and adolescents is a major public health issue worldwide (WHO, 2022). Adolescence is a critical period, marked by significant biological and psychosocial transformations, during which eating behaviours are formed and can persist into adulthood. Excess weight at this age is associated with an increased risk of metabolic, cardiovascular and psychosocial complications, some of which can appear early and persist long-term (Reilly & Kelly, 2011; Simmonds et al., 2016). Hence the importance of nutrition education interventions in adolescence lies not only in the immediate prevention of excess weight, but also in the possibility of having a lasting influence on health trajectories in adulthood.

The aetiology of childhood obesity is multifactorial. Beyond biological factors, the so-called 'obesogenic' environment, including socioeconomic conditions, parental education level, family eating habits and lifestyle, is a determinant of nutritional status of adolescents (Swinburn et al., 2011). In this context, several studies have identified protective factors, such as favourable family eating habits and better adherence to the Mediterranean diet, associated with a reduced risk of obesity and an improved cardiometabolic profile in young people (García Cabrera et al., 2015). However, the effect of these protective factors varies according to social and territorial contexts. Swinburn et al. (2011) demonstrated the importance of the environment in shaping dietary behaviors

and Rosi et al. (2024) highlighted the variability in adherence to the Mediterranean diet depending on living conditions. Thus, the results observed in high-income environments cannot be directly generalised to rural or disadvantaged areas.

In fact, the Mediterranean diet is not a uniform dietary model, it adapts to the cultural and geographical specificities of each country, or even within each region of a Mediterranean country. Nevertheless, it is basically characterised by a high consumption of fruits, vegetables, legumes, whole grains, olive oil and fish, combined with a low consumption of ultra-processed foods (Bach-Faig et al., 2011). In children and adolescents, this dietary model is recognised for facilitating better overall nutritional quality of food intake and a high density of essential micronutrients (Serra-Majem et al., 2004). Literature reviews have shown that the Mediterranean diet has a protective role for certain health markers, such as physical fitness, physical activity, inflammatory markers and quality of life (Masini et al., 2024). These favourable associations, however, often appear to be modulated by other factors and cannot be interpreted in isolation. In this regard, the synthesis by Masini et al. (2024) shows that, greater adherence to the Mediterranean diet among children and adolescents, is generally associated with more favourable profiles of physical activity, physical fitness and quality of life, but that the magnitude of these benefits remains heterogeneous depending on the indicators studied (Masini et al., 2024). An analysis conducted in five Mediterranean countries by Rosi et al. (2024) also highlighted significant variability in adherence according to living conditions and behavioural habits, suggesting that the level of physical activity, the family environment and, more broadly, socioeconomic conditions can modulate the concrete expression of the effects associated with this adherence (Rosi et al., 2024).

On the other hand, several tools have been developed to assess adherence to the Mediterranean diet among young people, with the KIDMED score (Mediterranean Diet Quality Index for children and adolescents) being the most widely used. Developed by Serra-Majem et al. (2004), this score provides a simple and validated way to assess the quality of the Mediterranean diet in children and adolescents. The methodological value of the KIDMED score in schools is significant, as it offers a simple tool for assessing adherence to the Mediterranean diet among young people. However, the interpretation of this index must remain contextualised. In line with the approach of Teixeira et al. (2022), who situate the analysis of children's and adolescents' eating habits

within specific life contexts, the data from Bober et al. (2025) also demonstrated that an adaptation and validation of KIDMED 2.0 were necessary for its use in a Polish pediatric population (Bober et al., 2025 ; Teixeira et al., 2022). These findings suggest that certain items of the score may not accurately reflect eating behaviours across different sociocultural environments and food availability.

Furthermore, numerous targeted interventions have been implemented in recent years to improve adherence to the Mediterranean diet among young people. Among these, interventional studies conducted in Europe in school and community settings have shown a significant increase in the KIDMED score following nutrition education programmes (Morelli et al., 2021; Roccaldo et al., 2024). However, these studies have highlighted a certain variability in individual responses, necessitating the adaptation of these interventions to factors such as age, socioeconomic context and the food environment. It is important to consider this variability, which suggests that the effectiveness of a nutrition intervention depends not only on its educational quality, but also on the social, cultural and institutional conditions of its implementation. Morelli et al. (2021) and Roccaldo et al. (2024) demonstrated that while a structured intervention in European schools could improve adherence to the Mediterranean diet, an analysis of school nutrition programmes conducted by Al-Jawaldeh et al. (2023) highlighted the diversity of existing programmes and the inadequacy of impact assessments in several countries of the Eastern Mediterranean region. These factors therefore call for caution when interpreting the direct applicability of European results to the rural contexts of North Africa, which are characterised by greater social and food vulnerability.

In Morocco, although the traditional diet is of Mediterranean type, adherence to this dietary pattern among the general adult population remains suboptimal, as reported by several national studies (Chamlal et al., 2025; Moustakim et al., 2023; Mziwira et al., 2024). Similar trends have been observed among adolescents, particularly in rural and socioeconomically disadvantaged areas, where recent studies have highlighted low to moderate adherence to the Mediterranean diet (Belaoufi et al., 2024; El Mokhtari et al., 2024 ; Mziwira et al., 2024). However, the available Moroccan data remain primarily descriptive and cross-sectional, documenting adherence levels but failing to adequately assess the effectiveness of structured educational interventions aimed at sustainably changing eating habits. This limitation is particularly pronounced in rural areas, where socioeconomic constraints, food accessibility and the daily environment can significantly influence the response to a nutrition

intervention (Belaoufi et al., 2024; El Mokhtari et al., 2024; Mziwira et al., 2024). To our knowledge, data assessing the impact of structured nutrition education interventions using the KIDMED score in Moroccan adolescents remain scarce or very limited, underscoring the need for further research in this field.

To address this gap, the present study aimed to assess the impact of a structured nutrition education intervention using the KIDMED score, while taking into account household socioeconomic characteristics and local food availability. Thus, beyond simply noting insufficient adherence to the Mediterranean diet, this study aimed to examine whether a contextualised intervention could produce measurable improvement in a rural Moroccan context characterised by specific social and dietary constraints. This approach followed on from the work of Al-Jawaldeh et al. (2023), who documented school-based nutrition programmes in the Eastern Mediterranean region and showed that, despite the diversity of interventions implemented, data assessing their impact remain limited in several countries of the region.

By providing original data from a rural Moroccan context, this work sought to contribute to the development of nutrition prevention strategies adapted to local realities, with the long-term goal of promoting sustainable healthy eating habits among adolescents.

Materials and methods

Study design and population

This before-and-after interventional study was conducted among 126 school-aged adolescents aged 14–18 years attending public schools in rural areas. Adherence to the Mediterranean diet was assessed before and after the nutrition education intervention.

The pre-intervention baseline data were collected between January and March 2025 and included sociodemographic characteristics, anthropometric measurements and adherence to the Mediterranean diet using the KIDMED questionnaire. The nutrition education intervention was then conducted between April and May 2025 and was followed soon after by the post-intervention evaluation carried out between September and October 2025.

The intervention consisted of a nutrition education programme designed to promote healthier food choices among adolescents, based on the principles of

the Mediterranean diet. The programme comprised three structured educational sessions, delivered once a week, each lasting 45 minutes. The sessions were conducted in school settings in a group format and were delivered by the author of this study using various types of teaching materials, including PowerPoint presentations, images, illustrations, and educational videos. The intervention focused on improving nutrition knowledge, promoting healthy eating habits, and strengthening adherence to the Mediterranean diet. The topics covered focused on the importance of the staple foods of the Mediterranean diet, namely the regular consumption of vegetables and fruits, legumes and whole grains, as well as reducing the consumption of foods high in sugar, salt and fat. The educational programme also aimed to raise awareness among adolescents about balanced, culturally appropriate food choices that are, to a limited extent, compatible with a perspective of food sustainability.

Collection of sociodemographic and socioeconomic data

Using a standardised questionnaire, data on sociodemographic characteristics, that is, age, gender, type of housing, parental family situation and educational level, were collected from the sample. Socioeconomic characteristics were also collected and included parental income and profession category (SPC), classified into four categories according to Orban-Seghebarth et al. (1982). The classification distinguishes between professionals and top executives (SPC1), managers and civil servants (SPC2), and manual workers, artisans, farmers, employees, drivers and salespeople (SPC3), divided into two subcategories: SPC3-a, including farmers and fishermen and SPC3-b, grouping other professions. Finally, category SPC4 includes people without paid employment. The households to which the adolescents studied belonged were also classified into three categories according to monthly income: low (< €300), medium (€300–500), and high (> €500). Housing tenure was categorised as owner or tenant.

Anthropometric parameter assessment

Anthropometric measurements were taken of the adolescents included in this study, in accordance with standardised recommendations. Weight and height were measured, and the age-specific BMI z-score was calculated. The World Health Organisation (WHO) growth reference values for children and adolescents aged 5 to 19 years were used to determine the BMI/age z-score values using the WHO AnthroPlus software (version 1.0.4), developed for the

application of the 2007 WHO reference values for school-aged children and adolescents (de Onis et al., 2007; WHO, 2009). The age-specific BMI z-scores are used to assess nutritional status in accordance with the approach recommended by the WHO for this age group. The waist-to-height ratio (WHtR) was also calculated, and a threshold value of 0.5 was used as an indicator of central adiposity in both boys and girls (McCarthy & Ashwell, 2006). Waist and hip circumferences were also measured to calculate the waist-to-hip ratio (WHR), as an indicator of fat distribution. In this analysis, these measurements were collected only at baseline, before the nutrition education intervention. Adherence to the Mediterranean diet was reassessed after the intervention. A third visit is planned to collect post-intervention anthropometric data and better assess the potential effect of the intervention on nutritional status.

Assessment of adherence to the Mediterranean Diet

The level of adherence to the Mediterranean diet was assessed before and after the intervention using the KIDMED index, as previously described by Belaoufi et al. (2024). The scores obtained were classified into three categories defining the level of adherence to the Mediterranean diet as 1: No adherence; 2: Moderate adherence; and 3: Strong adherence. The pre/post-intervention evaluation made it possible to assess the evolution of adherence to the Mediterranean diet following the educational intervention.

Statistical analysis

Statistical analysis was performed using SPSS software. Qualitative variables were described using counts and percentages and the quantitative variables were expressed as mean $\pm$ standard deviation (SD).

The comparison of anthropometric and nutritional parameters by gender was performed using Student's t-test for independent samples. When the assumption of homogeneity of variances was not met, Welch's correction was applied.

The change in adherence to the Mediterranean diet before and after the intervention, an ordinal variable measured in the same adolescents, was analysed using Friedman's test for paired data. Individual changes in adherence were classified into three categories (improvement, stability, or regression) according to the direction of change between the measurements

before and after the intervention, and presented as counts and percentages. The threshold for statistical significance was set at $p < 0.05$.

Ethical considerations

This study was conducted with the approval of the educational authorities. Informed consent from parents or legal guardians, as well as the assent of the adolescents was obtained prior to their participation in the study. Data confidentiality was ensured in accordance with applicable ethical principles.

Results

All participating adolescents in the study underwent pre- and post-intervention assessments. No dropouts were recorded between the two assessment periods. Table 1 shows that, among the 126 adolescents in the study, the majority were 17 to 18 years old (51.6%), 32.5% were between 14 and 15 years old and 15.9% were 16 years old. The gender distribution showed a predominance of girls (60.3%) compared to boys (39.7%). Regarding living conditions, most adolescents resided in houses (69.0%), while 30.2% lived in slums. As for family structure, almost all parents were married (96.8%). The parental education level was generally low: 81.0% of fathers and 84.1% of mothers had less than seven years of schooling, while a small proportion had attained a higher level of education (3.2% of fathers and 4.0% of mothers). In terms of socioeconomic status, 67.5% of households reported a monthly income of less than €300, indicating a predominantly disadvantaged economic situation, while only 2.4% of households belonged to the high-income category (more than €500). Regarding socio-professional category, mothers were almost exclusively employed in the third category of the socio-professional classification (farmers and fisherwomen: 99.2%), while this same category was largely predominant among fathers (88.8%), reflecting a primarily rural and agricultural socio-professional profile.

Table 1 Socio-Demographic and Socio-Economic Characteristics of the Study Adolescents (N=126)

Characteristics	Categories	n (%)
Age (yrs)	14-15	41 (32.5)
	16	20 (15.9)
	17-18	65 (51.6)
Gender	Girls	76 (60.3)
	Boys	50 (39.7)
Housing	Slums	39 (30.2)
	Houses	87 (69.0)
Family situation of parents	Married	122 (96.8)
	Widower / widow	4 (3.2)
Father's education level	< 7 yrs	102 (81.0)
	7-14 yrs	20 (15.9)
	> 14 yrs	4 (3.2)
Mothers' education level	< 7 yrs	106 (84.1)
	7-14 yrs	15 (11.9)
	> 14 yrs	5 (4.0)
Household monthly income (€)	< 300	85 (67.5)
	300-500	38 (30.2)
	> 500	3 (2.4)
Mothers' SPC	SPC2 : Civil servant	1 (0.8)
	SPC3 : Farmers and fishermen	125 (99.2)
Fathers' SPC*	SPC1	6 (4.8)
	SPC2	6 (4.8)
	SPC3	111 (88.8)
	SPC4	2 (1.6)

n: number in sub-sample; SPC : Socio-Professional Category

The results in table 2 show that the comparison of anthropometric and nutritional parameters by gender revealed statistically significant differences for some variables. Boys had a significantly higher mean weight than girls (64.38 ± 9.26 kg vs. 56.89 ± 10.02 kg ; $p < 0.001$), as well as a significantly greater mean height (176.84 ± 7.45 cm vs. 163.30 ± 4.94 cm ; $p < 0.001$).

The distribution of adiposity assessed by the waist-to-height ratio (WHtR) was significantly higher in girls (0.44 ± 0.07) than in boys (0.41 ± 0.05 ; $p = 0.016$), suggesting a tendency toward more pronounced central adiposity in girls. Conversely, the waist-to-hip ratio was significantly higher in boys (0.81 ± 0.10

vs. 0.76 ± 0.10 ; $p = 0.008$), reflecting gender-related differences in body fat distribution.

No statistically significant differences were observed between both genders for body mass index (BMI) ($p = 0.195$), waist circumference ($p = 0.429$), or hip circumference ($p = 0.062$), indicating comparable overall body size between the girls and boys in this population. Similarly, before the nutrition education intervention, the Mediterranean diet adherence score did not differ significantly between genders (6.46 ± 3.08 in girls vs. 7.08 ± 3.16 in boys; $p = 0.276$).

Table 2 Comparison of Anthropometric and Dietary Characteristics by Gender

Characteristics	Girls (n = 76) Mean $\pm$ SD	Boys (n = 50) Mean $\pm$ SD	p-value
Weight (kg)	56.89 ± 10.02	64.38 ± 9.26	< 0.001
Height (cm)	163.30 ± 4.94	176.84 ± 7.45	< 0.001
WHtR	0.44 ± 0.07	0.41 ± 0.05	0.016
BMI (kg/m ²)	21.31 ± 3.47	20.59 ± 2.73	0.195
WC (cm)	71.32 ± 11.35	72.80 ± 8.34	0.429
HC (cm)	93.68 ± 9.14	90.46 ± 9.76	0.062
WHR	0.76 ± 0.10	0.81 ± 0.10	0.008
MDS	6.46 ± 3.08	7.08 ± 3.16	0.276

BMI: Body Mass Index; WC: Waist Circumference; HC: Hip Circumference; WHR: Waist-to-Hip Ratio; WHtR: Waist-to-Height Ratio; MDS: Mediterranean Diet Adherence Score; SD: standard deviation

Table 3 presents the results of the assessment of adherence to the Mediterranean diet among adolescents before and after the educational intervention, as expressed by the Mediterranean Diet score (MDS). The table data show a higher mean adherence level after the intervention (1.83 ± 0.67) compared to that before the intervention (1.29 ± 0.50). This difference between the two periods, estimated by Friedman's test applied to paired ordinal data ($p < 0.001$) was highly significant, indicating an improvement of the MDS score after the nutrition education intervention and a positive impact of the intervention on adherence to the Mediterranean diet among the adolescents studied.

Table 3 Comparison of Adherence to the Mediterranean Diet Before and After the Nutrition Education Intervention among The Study Adolescents

Variable	Before intervention (Mean $\pm$ SD)	After intervention (Mean $\pm$ SD)	Statistical Test	p-value
Adherence to the MD (MDS)	1.29 $\pm$ 0.50	1.83 $\pm$ 0.67	Test de Friedman	< 0.001

MDS: Mediterranean Diet Adherence Score. Adherence level is an ordinal variable with three categories (1=No adherence; 2=Moderate adherence; 3=Strong adherence). The data correspond to paired measurements taken before and after the intervention in the same group of adolescents.

As shown in Table 4, analysis of changes in the individual score of adherence to the Mediterranean diet after the education intervention shows that the majority of adolescents (60.32%) experienced improved adherence in their level to the Mediterranean diet, moving to a higher adherence category after the intervention. This improvement was observed in more than 50% of the sample, suggesting a positive change in eating habits among a large proportion of adolescents.

Furthermore, 37.30% of adolescents maintained the same level of adherence before and after the intervention, indicating stable eating habits in this segment of the study population. This stability may reflect either a maintenance of a previously achieved level of adherence, or an absence of measurable change over the period considered. Conversely, a very small proportion of adolescents (2.3%) showed a decline in their level of adherence, falling to a lower category after the intervention.

The overall analysis using Friedman's test revealed a highly statistically significant change in adherence to the MD between the two periods ($p < 0.001$). This result confirms that the changes observed in adherence levels after the intervention were not due to chance and reflect an overall positive effect of the nutrition education intervention on adherence to this diet among the adolescents studied.

Table 4 Changes Affecting Adherence to the Mediterranean Diet After the Nutrition Education Intervention (N=126)

Change Type	Classification Criteria	n (%)	p-value
Improved adherence	MDS increased	76 (60.32 %)	P<0,001
No difference of adherence	No change of MDS	47 (37.30 %)	
Regression of adherence	MDS decreased	3 (2.3 %)	
Total		126 (100 %)	

The overall change was assessed using Friedman's test ($p < 0.001$). **n**: number in sub-sample;

Discussion

This study presents data on the impact of a targeted nutrition education intervention on adherence to the Mediterranean diet among Moroccan adolescents from disadvantaged rural areas, characterised by low socioeconomic status and parental education levels.

The influence of parental socioeconomic status and educational level on dietary behaviours and nutritional status has been highlighted in Morocco at both national and regional levels, including among rural adolescents and young adults (HCP, 2021). The results of this study show that the majority of adolescents belonged to low-income households (less than €300 per month), their parents being mostly farmers with limited education. An estimate of adherence to the Mediterranean diet among young Moroccans, carried out in a previous study using the KIDMED score, showed that it was generally low to moderate and strongly influenced by socio-economic, educational and environmental factors (Belaoufi et al., 2024). The disadvantaged socioeconomic background of these adolescents, reflected in particular by low household income and their parents' limited education level, must also be considered when interpreting the changes observed after the intervention. Indeed, these factors can influence both initial adherence to the Mediterranean diet and the adolescents' ability to sustainably adopt the promoted dietary behaviours.

This study revealed a higher waist-to-height ratio (WHtR) in girls, suggesting relatively more pronounced central adiposity than in boys. This finding is consistent with recent Moroccan data reporting significantly higher WHtR values and increased prevalence of abdominal adiposity in girls (Belaoufi et al., 2024; Lahyani et al., 2025). The importance of contextual and socio-

environmental determinants in the expression of abdominal adiposity has also been highlighted in younger schoolchildren, suggesting that these disparities can develop early and persist into adolescence (Lahyani et al., 2025). Another anthropometric index measured in this study was BMI, which showed no significant difference between girls and boys. Combined with WHtR, this suggests comparable overall body size and provides a better understanding of fat distribution in adolescents. Anthropometric differences by gender are included here among the descriptive characteristics of the baseline study population and not as the primary focus of the study, which was to examine the evolution of adherence to the Mediterranean diet after the intervention. The objective of this study is based on recent research showing that targeted educational and promotional interventions can positively modify young people's eating habits by improving their adherence to the Mediterranean diet. Indeed, data from a recent meta-analysis demonstrated an association between greater adherence to the Mediterranean diet and better health among young people (Dubey et al., 2025).

In Morocco, the importance of educational initiatives to improve the quality of local food among young people has been highlighted by recent data revealing low adherence to the Mediterranean diet and a trend toward a more Westernised diet among school-aged adolescents. These data also suggest that the adoption of the traditional Mediterranean diet model could be strengthened by the implementation of targeted nutrition programs (Belaoufi et al., 2024). The potential impact of nutrition interventions in school or community settings on adherence to healthy eating is confirmed by comparable studies conducted internationally. Furthermore, in the European context, interventions based on nutrition education have demonstrated a significant increase in KIDMED scores after a period of targeted instruction, although some behaviours may require complementary approaches for lasting change (Morelli et al., 2021).

In the present study, adherence to the Mediterranean diet was assessed using the KIDMED index and the results revealed its improvement after the nutrition intervention. This is evidenced by the statistically significant increase in the KIDMED score, from a mean of 1.29 ± 0.50 before the intervention to 1.83 ± 0.67 after. Moreover, the analysis using the Friedman test adapted to paired ordinal data confirms and indicates a beneficial effect of the intervention on adolescents' eating behaviors.

This also corroborates the international observations on structured nutrition education contributing to promoting healthier eating behaviors among adolescents (Rosi et al., 2024). However, the scientific literature is not unanimous, with some studies failing to demonstrate significant improvements in the quality of the Mediterranean diet or weight after educational interventions. Furthermore, recent reports have highlighted heterogeneity in the effects of school-based interventions on adolescent diets, suggesting the likely involvement of several factors in the effectiveness of such programmes, including the duration and intensity of the intervention, as well as the involvement of family and school staff. For example, improved adherence to the Mediterranean diet has been reported among adolescents following a programme combining nutrition education and physical activity, suggesting that a structured multi-component intervention can modify certain eating behaviours (Morelli et al., 2021). Conversely, a randomised trial conducted by Prieto-Zambrano et al. (2021) in adolescents did not significantly improve the quality of the Mediterranean diet or the level of physical activity after the intervention. Similarly, Martín-Crespo Blanco et al. (2022) reported a significant reduction in BMI in the intervention group, while the change in the overall KIDMED score remained more nuanced in preschool children, reflecting a less pronounced effect on short-term adherence to the diet. In contrast, a school-based trial in Italy confirmed that a prolonged educational intervention could improve adherence to the Mediterranean diet (Roccaldo et al., 2024). Overall, this research confirms that the effect of educational programmes is neither uniform nor immediate and that it varies according to the characteristics of the intervention, the duration of follow-up, the age of the adolescents and the level of involvement of the school and family.

In a randomised trial with preschool children, Martín-Crespo Blanco et al. (2022) evaluated an intervention based on a school garden; the authors observed a decrease in BMI in the intervention group, while the change in the overall KIDMED score between groups remained borderline statistically significant ($p = 0.076$). Conversely, some dietary behaviours improved more markedly; notably the consumption of legumes more than once a week, identified as a predictor of better diet quality in the intervention group ($OR = 1.382$; 95% CI: 1.126–1.695; $p = 0.009$) (Martín-Crespo Blanco et al., 2022). More recently, Roccaldo et al. (2024), in a long-term Italian school-based trial, showed that an educational programme led by trained teachers, combined with the distribution of vegetables and fruits, significantly improved optimal adherence to the Mediterranean diet. The proportion of children exhibiting

optimal adherence thus increased from 25.5% to 49.5% in girls and from 23.1% to 36.6% in boys ($p < 0.0001$ in both cases) (Roccaldo et al., 2024). A predominance of low or intermediate adherence levels has also been reported among school-aged adolescents, reflecting dietary habits often already established during adolescence. This may explain the high proportion of stable profiles observed after a limited-duration intervention. However, in the short term, without prolonged support and involving the family, there is little variation in the KIDMED score (Azekour et al., 2020).

In fact, lasting changes in eating habits have been reported in young populations using multiple interventions (Rosi et al., 2024). This finding is confirmed by the results of the present study, revealing an overall moderate adherence despite the significant improvement in the mean adherence score post-intervention. Furthermore, this result suggests the need for additional or extended educational measures to consolidate behavioural changes and ensure their long-term sustainability. This was also the case in Spain and Italy, where several school-based nutrition education programmes have reported that the majority of adolescents maintain their initial adherence category, while only a fraction progress to a higher category, despite an improvement in their KIDMED score (Martín-Crespo-Blanco et al., 2022; Roccaldo et al., 2024).

In this study, the results were analysed in light of data collected in some Mediterranean countries, although directly comparable data are lacking in others. This is the case for Maltese studies where data are limited, particularly regarding adherence to the Mediterranean diet among adolescents. A study conducted in Malta revealed that, despite their knowledge of the Mediterranean diet, adolescents often had unbalanced eating habits and their knowledge of diet-related non-communicable diseases remained low. The results of this research demonstrated the need for more explicit teaching of the Mediterranean diet in schools (Bugeja, E., 2015). The researcher also highlights the importance of developing more local research to better understand the determinants of young people's eating habits and to assess the relevance of tailored nutrition education interventions.

Individual transitions between Mediterranean diet adherence categories often remain limited in the short term, although a study conducted in Morocco highlighted the KIDMED test's particular sensitivity to overall group changes (El Mokhtari et al., 2024). The intervention programme in the present study improved adherence to the Mediterranean diet in 60.32% of the adolescents

who participated. Clinically, this result is significant because, despite the constraints specific to this age group, the improved adherence following the educational intervention in this large proportion demonstrates a genuine receptiveness to educational messages. This is consistent with the findings of Serra-Majem et al. (2004). These authors demonstrated that the KIDMED index they developed is a tool that highlights differences in diet quality between children and adolescents. They also emphasised that this population constitutes a priority target for nutrition interventions due to the significant changes observed in their eating habits (Serra-Majem et al., 2004). Similarly, the systematic review by Masini et al. (2024) also demonstrated improved adherence to the Mediterranean diet among children and adolescents, despite the limited and sometimes contradictory results of this study regarding anthropometric indicators, particularly BMI. This improvement is generally associated with beneficial effects on several dimensions of health, including physical activity, physical fitness, quality of life and reduced sedentary behaviour.

The decline in adherence observed in 2.3% of adolescents in this present study can be considered small, but suggests that certain external factors may temporarily mitigate the positive effects of nutrition education. Data from the study by Masini et al. (2024) also highlighted the heterogeneity of results observed among young people and the need to interpret dietary changes in light of multiple behavioural and contextual determinants.

Despite this diversity of individual trajectories, the Friedman test confirms a significant overall improvement in adherence to the MD after the intervention, which is consistent with the majority of interventional studies using the KIDMED. These findings also suggest that the nutrition programme was effective at the group level, while highlighting the need for longer, repeated interventions that integrate the family and school contexts in order to increase the proportion of individual improvements and limit regressions.

Conclusion

The data presented here highlight that improving adolescent nutrition depends not only on economic resources but also largely on nutrition education, awareness-raising, and behavioural support. This work provides a relevant scientific basis for developing nutrition education prevention strategies rooted in rural Moroccan contexts and geared towards the sustainable promotion of healthy lifestyles among younger generations.

Limitations

Among the strengths of this study is the interesting result obtained from the educational intervention regarding adolescents' adherence to the Mediterranean diet guidelines. Moreover, as this is a before-and-after intervention study, each participant is their own control.

However, this study also has weaknesses; most importantly, the short duration of adolescents' exposure to this intervention. Furthermore, as the results presented are part of a larger study, post-intervention anthropometric data are not included in this analysis (because they are not yet available). Thus, although this study allowed us to assess short-term changes in adherence to the Mediterranean diet, it has not yet been possible to examine the potential impact of the intervention on anthropometric parameters. A future third phase is planned to address this objective.

Finally, taking these limitations into account, the causal attribution of observed changes in adherence to the Mediterranean diet should be restricted to the nutritional intervention alone, and consequently, the observed effects should be interpreted with caution.

Recommendations and future direction

In light of the results obtained, several research and action avenues can be explored to strengthen and sustain the observed positive effects. Firstly, longer-term nutritional interventions, incorporating repeated sessions and longitudinal follow-up, would allow for the assessment of the stability of behavioural changes and the identification of factors that promote their maintenance in the medium and long term.

Integrating participatory approaches, actively involving adolescents in the design and implementation of the programmes, could also improve the understanding and application of nutritional messages to young people's daily lives

Furthermore, increased involvement from the family and school environment also appears essential. Awareness-raising activities for parents, particularly in rural areas, could foster greater consistency between the educational messages delivered to adolescents and dietary practices within the home. Similarly,

strengthening the role of schools, notably through the integration of nutritional education into curricula and the improvement of food options within schools, would be a strategic lever for promoting sustainable dietary behaviors. Including a control group in the study would also be of interest to more rigorously confirm the specific effect of the intervention and to better distinguish its impact from that of other contextual factors.

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