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Original Article

Association Between Dietary Quality, Socioeconomic Level, Body Mass Index, and Age in Adolescents (Eastern Algeria): A Cross-sectional Study

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Abstract

Aim: This article aims to evaluate the quality of adolescents' diet in Constantine (Eastern Algeria) and investigate factors associated with this quality: Socio-economic Level (SEL), nutritional status (BMI), and age.

Methods: A cross-sectional survey was conducted in Constantine (Eastern Algeria) in 2019 with 1126 adolescents (aged 11–19 years). The dietary data were collected by a 24-hr recall. The diet quality was assessed by a diet diversity score (DDS) calculated for 9 food groups (DDS above the mean reflects a diversified diet) and a mean adequacy ratio (MAR) calculated for 12 nutrients. MAR's cut-off value was "one." Weight and height were measured, and BMI was interpreted according to the World Health Organization reference values. The SEL was assessed using a socioeconomic classification score (SECS) according to parents' education level, profession, and other household information.

Results: The mean DDS was 3.97 $\pm$ 1.25. It was shifted to the lowest values compared to the theoretical mean value (4.5). Insufficient scores (DDS $\leq$4.5) were found in 65.0% of subjects. The mean MAR was 0.59 $\pm$ 0.20 and values <1 represented 79.1%. A significant negative correlation was recorded between age and MAR (r = –15%; $P < 0.0001$), and a positive correlation was found between it and SECS (r = 18%; $p < 0.0001$). BMI is inversely and significantly associated with MAR (r = –9.9%; P = 0.0009).

Conclusion: In addition to highlighting a low diversity and a poor adequacy with nutritional recommendations among adolescents in Algeria, this study underlines the significant effect of age, BMI, and socioeconomic level on the quality of diet.

Keywords: dietary diversity score (DDS), mean adequacy ratio (MAR), BMI, socioeconomic level, adolescents

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1. Introduction

It is difficult to give a precise definition for the concept of adolescence. Each person experiences the concept differently depending on physical, emotional, and cognitive maturity, as well as other factors. Although there is no internationally accepted definition, the WHO defines adolescents as those aged from 10 to 19 years, that is, those in their second decade of life [1]. In 2019, according to the latest United Nations estimates of the world total population, adolescents numbered 1.25 billion between 10 and 19 years, or 16% of the total world population [2]. In Algeria, they represent 15.3% (including 51.1% girls) of the total population, or 6,122,372 adolescents in 2015 [3].

Growth and development of adolescents are influenced by diet. This population combines a certain confusion between modern diet, which has a social identity charm, and traditional diet, which is part of their cultural identity [4]. In the Mediterranean basin, diet studies have revealed unfavorable trends in eating habits characterized by a high consumption of saturated fats and a low consumption of fruits and vegetables [5]. Disordered eating in adolescents has also been reported in previous studies from different parts of the world and from Arab countries [6]. In Algeria, studies have shown that adolescents, as their peers in developed and developing countries, accumulate dietary behaviors that are considered as risks to their health [7–12].

The diversity of diet is an essential component of the qualitative measurement of food consumption. The use of nutritional scores and indices for the measurement of diversity is not a new concept; however, it is relatively recent, at least, in developing countries. Research has demonstrated a positive relationship between dietary diversity or the overall quality of food intake and the nutritional status, growth, sociocultural factors, and the diet of children and adolescents in these countries [13–16].

The objective of this study was to evaluate the quality of adolescent's diet in Constantine (Eastern Algeria), using the diet diversity score (DDS) and the mean adequacy ratio (MAR). We also investigated factors associated with diet quality: Socioeconomic level (SEL), nutritional status (BMI), and age.

2. Methods

2.1. Area and subjects

The province of Constantine is located in the center of Eastern Algeria, 431 km from the capital Algiers to the West. It extends over an area of 2297.20 km^2 and is divided into 12 municipalities. The total population was 938,475 inhabitants in 2008, a density of 400 inhabitants/km^2 with a growth rate of 1.5%. The population under 15 represents 29% of the total population. In Constantine's municipality, the population includes 70,432 children and adolescents (34,555 girls) aged between six and 15 years. Among them, 66,590 (including 32,816 girls) were schooled with a scholarization rate of 94.5% [3].

2.2. Sampling technique

A multistage random sampling technique was used to recruit participants for this study. The study population comprised middle and secondary school students (aged 11 to 19) from Constantine's municipality. In the first stage, we selected districts with socioeconomic disparities. Four districts were, therefore, included in the study (two prestigious and two less prestigious). All public and private schools which include grades 11 to 19 years were eligible to participate in the study. Once selected, each district was contacted for a list of public and private schools. Within each district, 13 private and public (middle and secondary) schools were randomly selected. From each of the selected schools, a sample of three classes (first, second, and third grades) from middle schools and two classes (first and second grades) from secondary schools was randomly selected. All students from the selected classes were asked to participate in the study. The non-inclusion criteria of adolescents were terminal classes; atypical day, the day before the survey with the consumption of different-from-usual diet; and the monitoring of special diet. Among the selected districts and schools, 1260 students were selected, where 134 were excluded.

2.3. Data collection

The survey was carried out from May 2018 to March 2019 to consider the seasonal variability of the diet. A validated questionnaire was administered comprising three distinct parts: general information on adolescents, socioeconomic level (SEL) of the parents, and a 24 hr-recall for adolescent's dietary data collection. The anthropometric measurements were carried out according to the recommendations of the WHO [17]. Weight (kg) was measured with SECA scale (range 150 kg, accuracy 1 kg) and height (cm) using SECA measuring rod (range 2 m; accuracy 0.1 cm). Thinness, overweight, and obesity were defined for adolescents according to WHO reference values [18].

The SEL of adolescents was identified by three levels: low, medium, and high [19]. It was assessed by a validated socioeconomic classification score (SECS) using parents' profession and education level and other household information (type of housing, household size, and equipment).

2.4. Dietary assessment

To assess the quality of adolescents' diet, we chose nutritional indices widely applied in developing countries. The DDS [20] reflects the diversity of diet and the MAR [21] the adequacy of this diet to nutritional recommendations in terms of nutrients.

2.4.1. Dietary diversity

Cereal products; potatoes; fresh and dried legumes (vegetables); fruit; meat and derivatives; poultry and eggs; fish and seafoods; milk and dairy products; and added fat are the nine food groups selected for calculating DDS. The DDS represents the number of food groups consumed. Sweets and sweet drinks were not included in the calculation because they do not contribute to healthy dietary diversity. Nevertheless, their consumption frequency and the proportion of adolescents who had consumed these foods the day before the survey were calculated separately because they contribute to a large extent to the energy value of diet and not to dietary diversity beneficial for the subjects. The maximum DDS is, therefore, 9 points. Higher scores indicate more diversified diet.

2.4.2. Dietary adequacy

The MAR represents the average adequacy of the food intake according to nutritional recommendations. It represents the sum of the nutrient adequacy ratio (NAR) in certain nutrients. NARs are calculated for each adolescent based on gender and age. The MAR and the NAR are calculated according to the methodology described by Hatloy *et al.* [21]:

NAR = Intake of a nutrient × / recommended intake for the same nutrient ×

MAR = $\sum$ NARs / Number of nutrients ($\sum\times$)

In our study, NARs of 12 nutrients were calculated: protein, fiber, phosphorus, calcium, iron, vitamins C, B6, B9, B12, A, D, and E. The conversion of the quantities as recorded on the 24-hr recall into nutrients was carried out with the French Table Foods Composition of CIQUAL [23]. For the MAR, the reference values used are the recommended nutritional intakes (ANC) for the French population [24]. When the dietary intake of a given nutrient exceeds the ANC, the result is a NAR greater than "one." In this case, the NAR is reduced to "one" [21]. MAR values equal or close to one represent satisfactory adequacy with nutritional recommendations.

2.5. Statistical analysis

STATA 12.0 software was used for data entry and analysis. The electronic data entry file did not include any personal data concerning the adolescents being investigated. The results of the study were presented in percentage for qualitative variables; mean and standard deviation, minimum, maximum, and correlation coefficient for the quantitative variables.

A comparison of the means was carried out with unpaired Student's test for scores <30 and reduced deviation test for scores ≥ 30. The analysis of variance (ANOVA) was used for the comparison of several means while the Chi-square test was used for comparing the percentages. Bivariate analyses were performed using the Pearson's simple correlation test. The significance level was <0.05.

2.6. Ethical considerations

The study was approved by the Constantine Health Authorities, the National Education Direction, and the Institutional Review Board. A verbal informed consent was obtained from all adolescents.

3. Results

3.1. Characteristics of the sample

A total of 1126 questionnaires were returned and used in this study. The mean age of the adolescents was 14.5 ± 2.3 years (11–19 years) with 55.6% of them being girls. The mean BMI was 20.4 ± 3.8 kg/m^2 – underweight, overweight, and obesity representing 9.2%, 11.5%, and 5.8%, respectively, with no significant differences in gender (Table 1). Most adolescents had a medium SEL (46.9%). Higher levels were mostly observed in boys (31.6% *vs* 21.6%, $P = 0.04$).

3.2. Diet quality

3.2.1. Dietary diversity and associated factors

The evaluation of dietary diversity of adolescents by the consumption of different food groups during the last 24 hr showed a predominance of cereal products. In fact, 99.7% of the subjects consumed cereal products, 80.6% dairy products, 70.6% sweets, and 72.1% sugary drinks. The food groups with lower intake levels were added fat (7.8%)

Table 1: Characteristics of the study population (Constantine, Algeria 2019).

	Total (n = 1126)	Girls (n = 656)	Boys (n = 500)	P-value[a]
Age (yr) Mean ± SD	14.5 ± 2.3	14.5 ± 2.4	14.4 ± 2.3	0.65
11–12	23.1	21.7	24.8	0.22
13–15	44.2	46.6	41.2	0.06
16–19	32.7	31.5	34.0	0.36
BMI (kg/m^2) Mean ± SD	20.4 ± 3.8	20.2 ± 3.8	20.3 ± 3.7	0.89
Nutritional status (%)				
Underweight	9.2	10.7	7.4	0.05
Normal	73.4	72.7	74.4	0.51
Overweight	11.5	11.3	11.3	0.97
Obese	5.8	5.3	6.4	0.41
SEL (%)				
Low	27.1	29.2	24.4	0.06
Medium	46.9	49.2	44.0	0.08
High	26.0	21.6	31.6	0.04

[a]Significance of gender comparison; SD: Standard Deviation; BMI: Body Mass Index; SEL: Socioeconomic level

and fish and seafood (8.5%). The surveyed adolescent's diet was not very diversified. The mean DDS was 3.97 ± 1.25, and it was offset toward the lowest values. Insufficient scores (DDS ≤4.5) appeared in 65.0% of the subjects in comparison to satisfactory DDS for 35.0% of them (DDS >4.5). The comparison of the mean DDS values shows that there are significant differences across age groups and SEL (Table 2). Age influenced inversely dietary diversity in adolescents: the mean DDS was respectively 4.31 ± 1.32 and 3.80 ± 1.23 for 11–12-year olds and 16–19-year olds ($P < 0.0001$). The more SEL was increased, the more the diet of adolescents was diversified, DDS value was 3.77 ± 1.23 for adolescents from disadvantaged households, and 4.31 ± 1.34 for those from wealthy households ($P < 0.0001$). The comparison of DDS values by nutritional status indicated no significant differences.

3.2.2. Dietary adequacy and associated factors

The adolescents' diet was not in accordance with the nutritional recommendations. The mean MAR was 0.54 ± 0.14 for the total population. It decreased significantly ($P = 0.000$) with age (Table 2). The NARs were processed without the reduction of excess values. When we refer to NARs alone in this part, we mean raw NARs without modification (Table 3). Highest NAR was for free sugar. Its average value showed that its consumption is four times higher (4.05 ± 2.19) than the recommended intake. NARs were >0.67 for energy, protein, fat, and fiber. For micronutrients, the lowest NAR corresponded to

Table 2: DDS and MAR (mean ± SD) of adolescents by age, gender, nutritional status, and SEL.

	DDS	P value[a]	MAR	P value[b]
Age (yr)				
11–12	4.31 ± 1.32	0.0001	0.64 ± 0.13	0.000
13–15	3.92 ± 1.24		0.54 ± 0.14	
16–19	3.80 ± 1.23		0.48 ± 0.12	
Gender (%)				
Girls	3.91 ± 1.26	0.11	0.54 ± 0.14	0.10
Boys	4.08 ± 1.39		0.55 ± 0.15	
Nutritional status (%)				
Underweight	4.14 ± 1.25	0.06	0.54 ± 0.14	0.51
Normal	3.92 ± 1.33		0.54 ± 0.14	
Overweight	4.13 ± 1.32		0.56 ± 0.15	
Obese	4.35 ± 1.36		0.54 ± 0.16	
SEL (%)				
Low	3.77 ± 1.23	0.0001	0.54 ± 0.14	0.22
Medium	4.05 ± 1.20		0.54 ± 0.14	
Hight	4.31 ± 1.34		0.56 ± 0.14	

[a]Significance of mean DDS comparison by age, gender, nutritional status, and socioeconomic level;
[b]Significance of mean MAR comparison by age, gender, nutritional status, and socioeconomic level;
SD: Standard Deviation; SEL: Socioeconomic level

intakes of vitamin A (0.36 ± 1.63), vitamin D (0.42 ± 0.56), and calcium (0.48 ± 0.31), which represented respectively 36%, 42%, and 48% of the recommendations. NAR values showed that B group vitamins intake was better covered than those of other micronutrients, except for phosphorus. The consumption of calcium and vitamins B_6, B_9, D, and E for girls was far from the nutritional recommendations; while for boys, it was phosphorus and vitamin B_{12}. Age influenced positively the NAR for calcium and negatively for vitamin A. Iron and vitamin NARs were elevated in adolescents from higher socioeconomic groups (Figure 1).

The mean dietary adequacy (MAR) is positively correlated (r = 33%; $P < 0.0001$) with dietary diversity (Figure 2). It was significantly and inversly associated with age (r = –38%; P = 0.0000) and BMI (r = –9.9%; P = 0.0009). The analysis of associations between DDS and NARs of different nutrients (Table 3) show positive significant correlations, although they were low in most cases. The strongest correlations were noted for protein, energy, and free sugar. For minerals, all correlation coefficients were <0.4 despite being significantly positive, except for vitamin A. The highest correlation was recorded between DDS and vitamin B6 adequacy and the lowest between DDS and vitamin B12 and iron intakes.

a.

b.

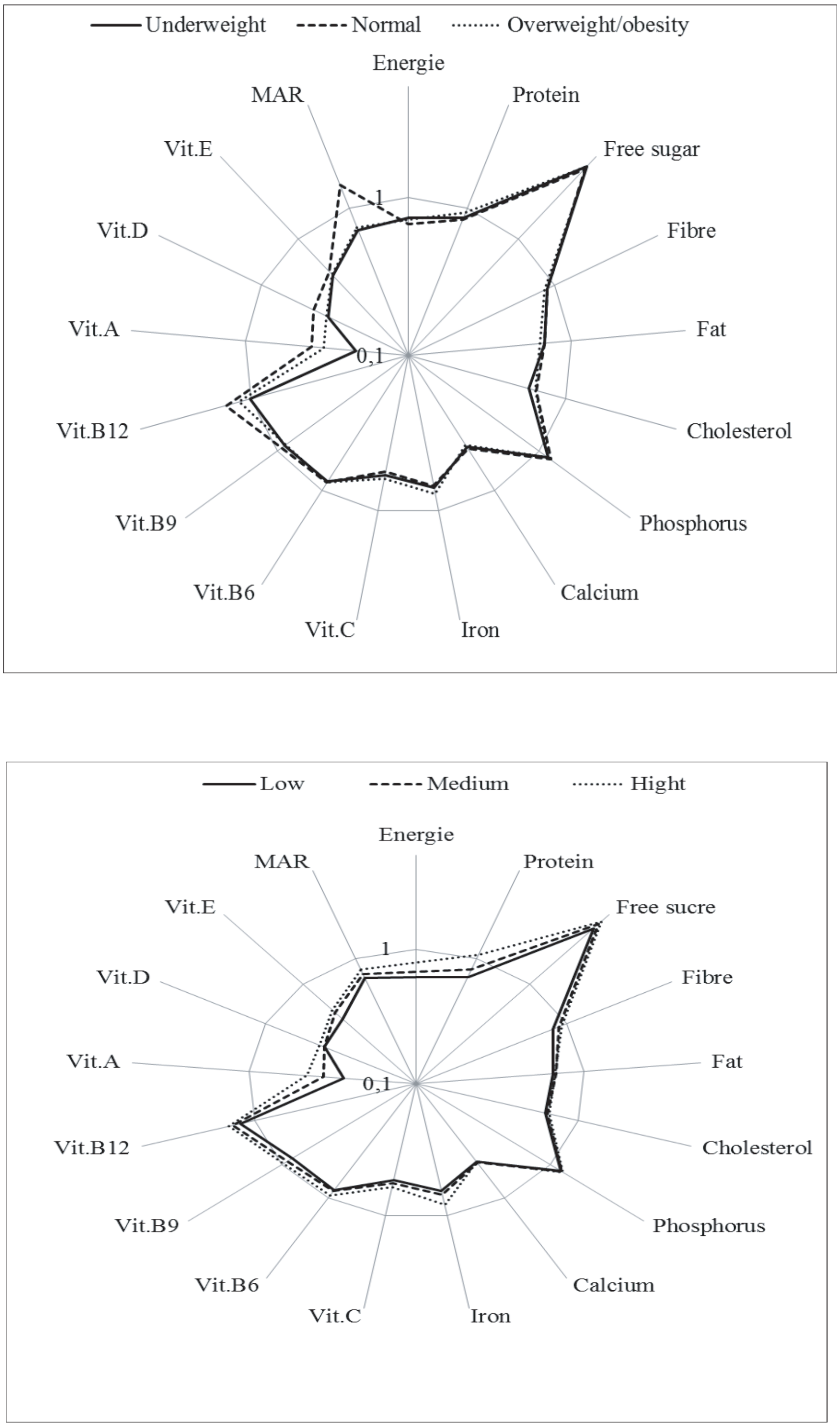

Figure 1: Comparison of NARs and MAR with ANC according to nutritional status and SEL. (a) NARs and MAR with ANC by nutritional status. (b) NARs and MAR with ANC by SEL.

4. Discussion

TABLE 3: NAR values, adolescents below recommendations and Pearson's correlation coefficients between DDS and NARs.

	NARs		Adolescents below ANC		Correlation coefficients with DDS	
	Mean ± SD	**[Min – Max]**	< 75%	< 100%	**r**	**P-value[a]**
Proteins	0.66 ± 0.31	[0.06 – 3.66]	62.3	80.8	0.41	< 0.0001
Fiber	0.67 ± 0.32	[0.03 – 3.00]	55.8	70.5	0.26	< 0.0001
Calcium	0.45 ± 0.27	[0.02 – 2.2]	82.0	94.0	0.3	< 0.0001
Iron	0.51 ± 0.32	[0.06 – 1.00]	68.7	84.5	0.14	< 0.0001
Vitamine C	0.48 ± 0.35	[0.00 – 1.00]	94.8	96.3	0.35	< 0.0001
Vitamine B_6	0.70 ± 0.28	[0.00 – 1.00]	86.8	92.5	0.38	< 0.0001
Vitamine B_9	0.71 ± 0.29	[0.00 – 1.09]	79.9	86.9	0.34	< 0.0001
Vitamine B_{12}	0.70 ± 0.33	[0.00 – 3.30]	70.1	80.4	0.16	0.0014
Vitamine A	0.23 ± 0.24	[0.00 – 2.44]	52.2	69.1	0.04	0.1325
Vitamine D	0.35 ± 0.31	[0.00 – 2.26]	50.3	66.3	0.25	< 0.0001
Vitamine E	0.42 ± 0.31	[0.00 – 1.00]	47.7	59.7	0.16	0.0012
MAR	**0.54 ± 0.14**	**[0.13 – 0.97]**	**91.2**	**100.0**	**0.33**	< **0.0001**

NAR: Nutrient adequacy ratio; ANC: Apports nutritionnels Conseillés; SD: Standard Deviation; min: minimum; max: maximum; DDS: Dietary diversity score; MAR: Mean adequacy ratio; [a]Significance of the correlation between NARs and DDS

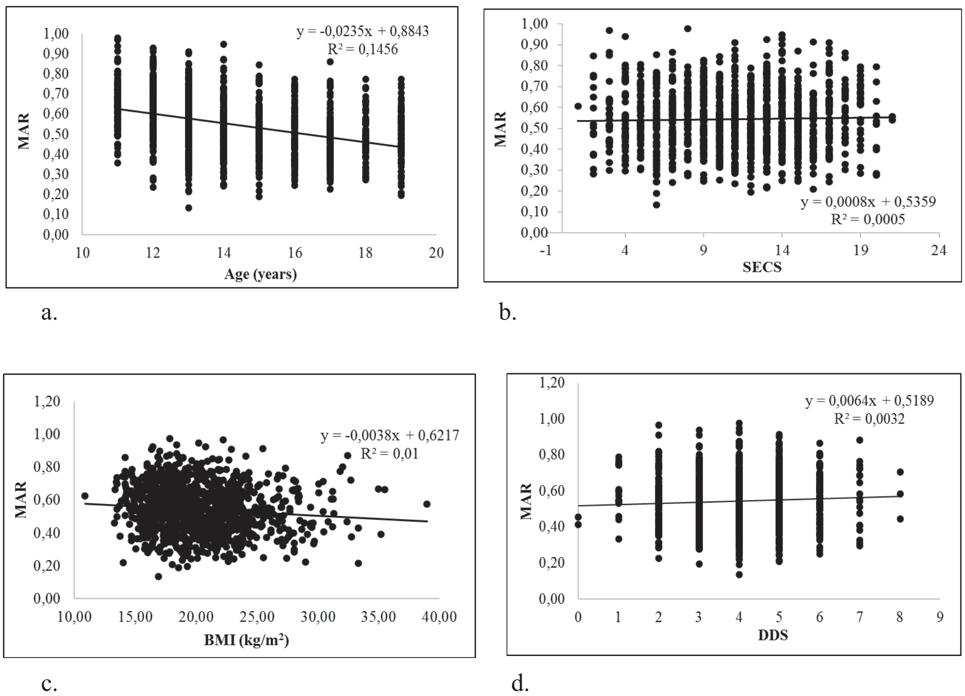

Figure 2: Association between MAR and age, SECS, BMI, and DDS. (a) MAR and age. (b) MAR and SECS. (c) MAR and BMI. (d) MAR and DDS.

4.1. Diet diversity and associated factors

Diversity scores do not indicate consumed food quantities, because the evaluation is qualitative. The mean DDS value for our population shifts to lower values. The comparison with other studies is difficult due to methodological differences. Indeed, the number of food groups included in the calculation of DDS is very different; for this study, nine food groups were considered. In Morocco, the DDS has been calculated for 12 food groups in adolescents aged from 12 to 16 years [25]. In Ethiopia, a study conducted in 2018 [26] showed a DDS of 5.76 ± 1.81 in 778 adolescent girls, which reflects a good diversity compared to the required value of 5. Among Iranian adolescents (11–18 years old) [27], the mean DDS was 5.93 ± 0.88 (in a maximum of 10). In France, adolescents and young people (12–25 years old), almost systematically, had the consumption that was far from the nutritional recommendations compared to other age groups. They had a lower dietary diversity, a low consumption of dairy products, fish, fruits, and vegetables. The consumption of fruits and vegetables were the limiting factors for dietary diversity in the population group [28]. These observations were also recorded in most European Union countries. The results of the HELENA study also confirm that dietary diversity among adolescents in European countries is average. The most consumed food groups are dairy products and meat, especially among adolescents in Northern countries. Cheese, legumes, and vegetables are the least consumed [29].

Among the adolescents surveyed in Constantine, age and SEL are the most influential factors of dietary diversity. This was also observed in 778 adolescent girls attending school in Ethiopia [26]. The study confirmed that the diet quality assessed by DDS is better in urban areas and among adolescent girls living in high-income areas. In Northern Mediterranean, Grosso and Galvano [30] confirmed that better food quality in adolescents is inversely associated with age. It is positively related to SEL assessed according to the parents' education. After analyzing the results of several studies, the authors concluded that SEL is the most important determinant of adolescent dietary quality. In Europe, the results of the HELENA study confirmed that the socioeconomic status assessed by parents' education and occupation is an influential factor on the dietary quality of adolescents [29, 31]. The Pralimap-Ines study of 1142 adolescents (France) confirmed that the more the social gradient increases, the better is the diet quality [32]. A systematic literature review published in 2018 on the influence of living standards on eating behaviors for adolescents (12–18 years) showed that an adolescent from a high socioeconomic environment has a healthier eating behavior than a teenager from a low socioeconomic environment [33]. In 2019, a study of 487 Iranian adolescents aged between 10 and 12 years confirmed that the nutritional status assessed by BMI has no significant association with dietary diversity assessed by DDS [15]. This was the conclusion from the meta-analysis and systematic review on the correlation between DDS and obesity in 2019 [34]. The authors confirmed that no association was observed between DDS and BMI. They explained this result by the differences between DDS methodologies. Indeed, the number of food groups included in the calculations makes the comparison difficult. However, in Iranian adolescents, it was concluded that there was a significant positive association between DDS and obesity. The mean DDS was higher in participants with obesity (5.65 $\pm$ 1.32) than that in normal-weight individuals (4.97 $\pm$ 1.42) ($P < 0.001$) [35].

4.2. Diet adequacy and associated factors

Our calculated MAR reflects an average adequacy of adolescents' diet according to the nutritional recommendations. The number of nutrients included in MAR calculation varies greatly according to the authors. In Algeria, no study has been published on the assessment of global-diet adequacy with the nutritional recommendations using MAR. In 2015, Allioua *et al.* [9] published the results from a study investigating the relationship between diet and overweight/obesity in adolescents aged between 10 and 17 in Tlemcen (Western Algeria). The authors calculated the NARs for 16 micronutrients without calculating the MAR. In Spain, the MAR calculated for children, adolescents, and young people (2–24-year old) for 7, 9, 12, and 14 nutrients were 0.91; 0.92; 0.86; and 0.85, respectively. Whatever the number of nutrients included in its calculation; the MAR of Spanish adolescents remains close to optimal adequacy [36]. Recently published, the results of the ELANS Study carried out in eight Latin American countries gave a MAR of 0.83 $\pm$ 0.06 for the total population (⊠15 years) [37].

Among the studied factors, the nutritional status (assessed by BMI) and age seem to have a negative effect on MAR among adolescents in Constantine. Allioua *et al.* [9] showed that NARs of vitamin C and B_2 decrease according to BMI only for girls, whereas those of vitamin D, vitamin A, and calcium increase only for boys. At the same time, the authors reported an increase in NARs for phosphorus and vitamins B1 and E with BMI for boys and girls. For our adolescents, no significant association was observed between BMI and NAR values. In Tunisia, the nutritional status of adolescents has no effect on the subjects' food consumption [38]. However, age and gender were significantly associated with dietary adequacy assessed by MAR or NARs. Most NARs decrease with age, which means that Tunisian adolescents, as they grow older, deviate from the nutritional recommendations. This was also observed, for age, in their peers in Constantine. In Latin American countries, the MAR increased significantly among socioeconomic status [37]. The MAR that we calculated is positively correlated with DDS. This was observed in several studies [5, 14, 39]. In Iranian adolescents, the correlation coefficients of different nutrients with DDS vary from 0.05 for vitamin A to 0.35 for calcium [40]. For adolescents in Constantine, the lowest correlation with DDS was noted for vitamin A. Therefore, a literature review [41] demonstrated that DDS must be used as an indicator for a healthy diet and not as an indicator for nutritional adequacy. So, two meta-analyses [41, 42] concluded that it is time to conduct studies to harmonize and standardize methods for calculating nutritional indices, in particular DDS, in order to facilitate international comparisons between studies. This should contribute to enhancing studies of the effect of food on human health and food safety in a global way. In developing countries, the absence of local recommendations is one of the main limitations of diet quality studies. In theory, the choice of reference of nutritional recommendations should be made based on population characteristics and their eating habits. Otherwise, the adoption of recommendations defined by other countries remains a necessity.

Limitations of this study include the absence of local recommendations to establishing scores. The French recommendations are the most used for consumer studies carried out in Algeria. However, the fact of belonging in the Mediterranean basin makes the populations more or less close: the same types of food, the same seasonal distribution of fruits and vegetables, consumption frequency of bread, grain products, meat, and rice. Another limitation is the large number of items in the that requires more time per subject.

5. Conclusion

This study revealed a diet quality far from nutritional guidelines and recommendations in Algerian adolescents. The calculated DDS indicates a poorly diversified diet. This result is confirmed by the quantitative indices that were calculated. The MAR is far from the ideal value of "one," which indicates an optimal adequacy to nutritional recommendations. Adolescents' diet quality is significantly influenced by age, nutritional status (assessed by BMI), and socioeconomic level. Educating Constantine's teenagers to reduce the consumption of food with a high-energy density and to encourage the consumption of fruits and vegetables is essential to improve the quality of their diet.

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Conflict of Interest

The authors have no conflict of interest to report.

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