Article title: Do adolescents accurately evaluate their diet quality? The HELENA study

Short running head: adolescents' dietary awareness

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Abbreviations: Healthy Lifestyle in Europe by Nutrition in Adolescence (HELENA), Diet Quality Index for Adolescent (DQI-A), HELENA Dietary Intake Assessment Tool (HELENA-DIAT), Healthy Lifestyle in Europe by Nutrition in Adolescence (HELENA), Flemish food-based dietary guidelines (FBDGs), Body mass index (BMI), International Standard Classification of Education (ISCED).

SUMMARY

Background and aims: The aim of this study was to assess the diet quality awareness and associated factors in a large sample of European adolescents.

Methods: The study included 3389 healthy adolescents, aged 12.5–17.5 years, who participated in the Healthy Lifestyle in Europe by Nutrition in Adolescence (HELENA) Study. The adolescents' diet quality was based on repeated 24 h recalls and scored into a Diet Quality Index for Adolescents (DQI-A) considering four components: meal, equilibrium, diversity and quality. A self-rated diet quality questionnaire was administered to adolescents to assess their dietary awareness. The association of DQI-A with dietary awareness was studied using a linear mixed model including the center as the random effect and dietary awareness as the fixed effect.

Results: There was a positive association between DQI-A scores and diet quality perception levels ($p < 0.0001$). The mean DQI-A was 59.0 (SD = 14.8) in adolescents with a low dietary awareness compared with 65.4 (SD = 12.6) in adolescents with high dietary awareness ($p < 0.0001$). Similar results were found for all the DQI components. When analyses were stratified, we found a significant heterogeneity across the nutritional status, with no significant association between DQI-A and dietary awareness level in obese adolescents, but a positive association in overweight, normal and undernourished groups. We found also a significant heterogeneity associated with the lunch location (school or home). No other factor affected dietary awareness (gender, pubertal status and maternal educational level).

Conclusion: European adolescents evaluate well their food quality whatever their pubertal status, gender and parental educational level, except for the obese who are not able to assess their diet quality. Improving the dietary awareness in obese adolescents might help to induce behavioral changes.

Keywords: Youth; Assessment; Nutrition; Awareness; Epidemiology study

1. Introduction

The prevalence of obesity has tripled in European countries in the last 30 years, and continues to rise at an alarming rate, especially in young people [1]. Overweight and obesity have many health consequences, making prevention particularly important [2]. In children, dietary habits are closely related to overweight and obesity [3-4].

Adolescence represents a period during which multiple physiological and psychological changes occur that considerably affect dietary habits [5-6]. The rapid physical growth that occurs during this period is associated with an increase in nutritional needs. Adolescence is marked by an increasing intake of energy-dense foods that are low in nutrients such as snacks and sugar-sweetened beverages and a decrease in intake of nutrient-dense foods such as fruits and vegetables [7-9]. Intervention or promotion programs for a healthy diet have been shown to have limited success in childhood and adolescence [10-11]. Lack of awareness of personal dietary habits has been identified as a major barrier to motivating adults to change to healthier diets [12]. We hypothesized that a similar barrier would apply for adolescents. Indeed, adolescents may think that they achieve healthy dietary habits because they wrongly assess their diet quality.

Therefore, the aim of the present study was to examine the diet quality awareness in a large sample of European adolescents. A secondary aim was to investigate factors associated with diet quality awareness.

2. Methods

2.1 Study design

The Healthy Lifestyle in Europe by Nutrition in Adolescence Cross-Sectional Study (HELENA-CSS) is a multicenter study performed in 10 European cities belonging to nine

89 countries. The HELENA-CSS was designed to obtain reliable and comparable data on
90 nutrition and health-related parameters from a sample of European adolescents aged 12.5 –
91 17.5 yr. A sample of 3,528 adolescents met the HELENA general inclusion criteria. A
92 detailed description of the HELENA study's methodology and sampling has been published
93 elsewhere [13-15].

94 Written, informed consent was obtained from the adolescent and the parents. The
95 HELENA study was approved by the local ethics committee in each country, and all
96 procedures were performed in accordance with the ethical standards of the Helsinki
97 Declaration of 1975 as revised in 2008 and the European Good Clinical Practices [16].

98 *2.2 Measurements*

99 *2.2.1 Self-rated diet quality*

100 Self-rated diet quality was assessed using a questionnaire. The adolescent was asked the
101 single question: "Your diet is: rather unhealthy, not healthy or unhealthy, rather healthy,
102 healthy, very healthy". A healthy eating was defined as "a healthy diet is a well-balanced diet
103 which contains a lot of fruit, vegetables and dairy products, a good portion of starchy foods
104 like bread, potatoes and pasta, a moderate portion of meat or fish, and not too much fat and
105 sugar. Also the intake of a large amount of fluid is very important in a healthy diet. The
106 energy content of a healthy diet is in accordance with the needs of the human body" [17]. For
107 the assessment of diet quality, the answers were classified *a priori* into three categories: low
108 when the answer was "rather unhealthy" or "not healthy or unhealthy", medium when the
109 answer was "rather healthy" and high when the answer was "healthy" or "very healthy". This
110 question about awareness was extracted from a healthy diet determinants questionnaire that
111 has been previously found to be reliable and valid, specifically awareness question correlated
112 well with fresh fruit, soft drinks and ascorbic acid [18].

113 *2.2.2 Diet quality assessment*

114 Dietary intake was assessed by two nonconsecutive 24-hour recalls performed on any
115 two convenient days of the week [19]. The 24-hour recalls were recorded using a self-
116 administered, computer-based HELENA Dietary Intake Assessment Tool (HELENA-DIAT)
117 that has been validated in European adolescents [20]. Detailed descriptions of data collection
118 and analysis have been published elsewhere [20-24].

119 *2.2.3 Participants' characteristics*

120 Weight was measured in light clothes, without shoes, to the nearest 0.1 kg using an
121 electronic scale (SECA 871; SECA, Hamburg, Germany). Height was measured without
122 shoes to the nearest 0.1 cm using a telescopic height-measuring instrument (SECA 225;
123 SECA). Body mass index (BMI) was calculated as weight (kg)/height^2 (m^2). Nutritional status
124 was assessed according to the International Obesity Task Force scale [25]. Pubertal status was
125 assessed by a physician through direct observation according to Tanner and Whitehouse [26].
126 Maternal educational level was classified into one of four categories using a specific
127 questionnaire adapted from the International Standard Classification of Education (ISCED)
128 (http://www.uis.unesco.org/ Library/Documents/isced97-en.pdf), and was scored as 1:
129 primary and lower education (levels 0, 1 and 2 in the ISCED classification); 2: higher
130 secondary (levels 3 and 4 in the ISCED classification); and 3: tertiary (levels 5 and 6 in the
131 ISCED classification).

132 *2.3 Statistical analysis*

133 Data are presented as percentages for qualitative variables and mean ± standard
134 deviation (SD) for quantitative variables. Normality of distribution was checked graphically
135 and using the Shapiro–Wilk test.

To assess the selection bias related to missing or incomplete data, the main characteristics of the included and nonincluded adolescents were compared using a Student *t*-test for quantitative variables, a chi-square test for categorical variables and the Mantel–Haenszel trend test for qualitative ordinal variables.

The association of DQI-A with dietary awareness was studied using a linear mixed model including the center as a random effect and diet quality perception level as the fixed effect (treated as an ordinal factor). We performed key subgroup analyses based on gender, pubertal status, nutritional status, maternal educational level and place adolescents used to have lunch (school or home). Heterogeneity in the association of DQI-A with dietary awareness level across subgroups was assessed by adding a multiplicative term into the linear mixed model.

All statistical tests were performed at a 2-tailed α level of 0.05. Data were analyzed using SAS version 9.4 [SAS Institute Inc., Cary, NC 27513, USA].

3. Results

Of 3528 adolescents meeting the inclusion criteria, 3389 (96%) were finally included in the statistical analysis after excluding those with missing or incomplete data for self-rated quality of diet. Characteristics of the population studied are presented in Table 1. Except for maternal educational level, there were no significant differences found between the included and nonincluded groups.

As shown in Figure 1, the DQI-A score increased gradually with the adolescent's dietary awareness level ($p < 0.0001$). The mean DQI-A was 59.0 (SD = 14.8) in adolescents with a low dietary awareness compared with 65.4 (SD = 12.6) in adolescents with a high dietary awareness. Similar results were found for all the DQI components.

When analyses were stratified according to key subgroups, no heterogeneity in the association of DQI-A and dietary awareness level was found for gender, pubertal status or maternal education level (Table 2). We found a significant heterogeneity associated with the lunch location (school or home). The positive association between DQI-A and diet awareness was stronger in adolescents who eat at home than those eating at school (Table 2). In addition, we found also a significant heterogeneity associated with nutritional status, with obese adolescents showing no significant association between DQI-A and dietary awareness, while a positive association was found for the overweight, normal and underweight groups (Table 2). The mean difference in DQI-A between the highest and lowest dietary awareness level was 9.3 in the underweight, 6.9 in those of normal weight, 5.2 in the overweight and 0.5 in the obese. Similar results were found for each DQI component (Table 3).

4. Discussion

Although several studies have been performed to evaluate the perception of dietary intake in children and adolescents, our study is the first to investigate the relationship between diet quality and the awareness of diet quality in European adolescents [27]. We hypothesized that a lack of awareness of personal dietary habits could be a major barrier for intervention programs aimed at promoting a healthy diet.

Unexpectedly, our main finding was that European adolescents, regardless of gender, pubertal status, maternal educational level and lunch location, correctly assess their own diet quality. While adolescents have been shown to have difficulties in qualifying their daily physical activity (they tend to overestimate their physical activity patterns), our data show that is not the case for their assessment of diet quality [28]. This probably results from education and information about a “healthy” diet in the European countries included in the study.

183 Gender, pubertal status or educational level did not affect diet quality awareness, whereas
184 these variables were demonstrated to have an influence on physical activity awareness [29].
185 Another important finding from our study is that obese adolescents do not have a valid
186 perception of their diet quality. In addition to underestimating their weight and energy intake,
187 our results show that obese adolescents do not discriminate well between a healthy or
188 unhealthy diet [28-32]. This is an additional factor that could contribute to the failure of
189 intervention programs that aim to reduce obesity. Our observation that obese adolescents
190 misreport their diet quality emphasizes the importance of improving awareness of diet quality,
191 the first step in any intervention to promote a healthy diet. Based on the results presented in
192 our study, regular feedback to obese adolescents on their dietary quality might be beneficial
193 and could motivate them to adjust their own diet throughout the day. New technology, such as
194 nutrition applications for mobile devices, could be used to give regular and rapid feedback on
195 dietary intake quality, and therefore might improve dietary intake quality perception and
196 behaviors [33-35]. This method presents a great opportunity to modify awareness and might
197 instill healthy behaviors, while providing objective information about individual dietary
198 quality might bring about a more realistic estimation of dietary quality by obese European
199 adolescents. Another possible explanation for the misperception of diet quality by obese
200 adolescents is the influence of social desirability (the tendency to respond so as to avoid
201 criticism) and social approval (the tendency to seek praise), which can bias answers in self-
202 reporting [35].
203 In our study, we found a stronger positive association between DQI-A and diet
204 awareness in adolescents who eat at home compared to those eating at school. This difference
205 might be due to the influence of the family on healthy diet awareness. However a significant
206 positive between DQI-A and awareness was found both in adolescent eating at home and
207 those eating at school.

208 The current study has strengths and limitations. The strengths of the study are the large
209 sample size of adolescents in 10 European cities, the use of standardized procedures, and the
210 strong methodology used to assess dietary habits [36]. The limitations of the study include the
211 cross-sectional design with observed associations, which cannot be interpreted to reflect
212 causal relationships. In addition, even though the HELENA-DIAT has been validated against
213 dietary recall with an interviewer, the main limitation is the subjectivity, especially in obese
214 people, of the assessment of dietary intake that was evaluated only by the adolescent
215 participants. Then, as this study was performed ten years ago (2006-2007), we could not
216 exclude our results represent the present situation.

217 **5. Conclusions**

218 Adolescents evaluate well their food quality independent of their pubertal status, gender
219 and parental educational level, except for obese adolescents who are not able to assess
220 accurately their diet quality. Improving dietary awareness in obese adolescents might help to
221 induce behavioral changes.

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Conflict of interest

The authors do not have any competing interests.

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370

371 **Legends**

372 **Figure 1.** DQI-A according to the adolescents' diet quality awareness.

373

Table 1. Comparison of mean characteristics between the included and non-included adolescents

	Included	**Not included**	**P**
Number of adolescents	3389	139	
Gender (%*boys*)	47.4	55.4	0.06
Age (*yr*)	14.7 ± 1.2	14.7 ± 1.3	0.69
Nutritional status (%*UW/%NW/%OW/%O*)[a]	6.2 / 70.9 / 17.3 / 5.6	3.6 / 67.6 / 22.3 / 6.5	0.09
Pubertal status (%*II/%III/%IV/%V*)[b]	6.0 / 22.3 / 42.2 / 29.5	8.0 / 27.0 / 41.0 / 24.0	0.11
Mother education level (%*I/%II/%III*)[c]	34.7 / 31.4 / 33.9	47.1 / 30.0 / 22.9	**0.02**
Place adolescents used to have lunch *(%school*)	23.8	26.1	0.68
For boys			
Z-score for height	0.64 ± 1.04	0.56 ± 1.04	0.53
Z-score for weight	0.68 ± 0.98	0.80 ± 0.97	0.29
Z-score for BMI *	0.40 ± 1.00	0.60 ± 1.00	0.08
For girls			
Z-score for height	0.31 ± 1.02	0.21 ± 0.97	0.47
Z-score for weight	0.45 ± 0.83	0.43 ± 0.69	0.86
Z-score for BMI*	0.34 ± 0.87	0.35 ± 0.80	0.94

[a] Nutritional status: underweight (UW), normal weight (NW), overweight (OW), obese (O)

[b] Pubertal status staging according to Tanner

[c] Education level: lower education (I); higher secondary education (II); higher education or university degree (III).

* Body Mass Index

Table 2. DQI-A according to the adolescents' diet quality awareness and key subgroups

	Diet quality self-assessment				
	Low	**Median**	**High**	**P***	**P het**
Gender					
Boys	56.0 (15.6)**	61.7 (13.8)	63.4 (13.2)	**<0.0001**	0.59
Girls	61.5 (13.6)	63.5 (13.2)	67.3 (11.7)	**<0.0001**	
Nutritional status					
Undernourished	57.0 (12.8)	62.6 (13.6)	66.3 (12.8)	**<0.0001**	**0.006**
Normal Weight	58.7 (14.9)	62.2 (13.3)	65.6 (12.3)	**<0.0001**	
Overweight	59.2 (15.1)	64.0 (14.0)	64.4 (13.7)	**0.002**	
Obese	62.2 (14.3)	67.8 (14.7)	62.7 (13.9)	0.42	
Pubertal status					
II	60.0 (13.6)	63.3 (11.7)	65.4 (13.0)	**0.016**	0.12
III	58.9 (14.9)	64.4 (12.9)	65.0 (13.1)	**<0.0001**	
IV	58.9 (14.7)	61.8 (13.8)	64.5 (13.1)	**<0.0001**	
V	58.8 (15.4)	62.7 (13.8)	67.5 (10.9)	**<0.0001**	
Mother education level					
I	55.7 (15.3)	59.0 (14.3)	59.7 (13.9)	**<0.0001**	0.27
II	61.3 (13.6)	64.0 (12.8)	66.5 (11.3)	**<0.0001**	
III	62.3 (13.4)	65.6 (12.1)	68.9 (10.6)	**<0.0001**	
Place adolescents used to have lunch					
School	61.5 (12.4)	64.3 (12.3)	66.9 (11.6)	**<0.0001**	**0.043**
Home	58.8 (15.3)	62.6 (14.0)	66.1 (12.6)	**<0.0001**	

P het indicates p-values for heterogeneity in relation to DQI-A and diet awareness level across key subgroups.
* P for trend adjusted for center using linear mixed effect model (diet perception level was treated as an ordinal factor).
**mean (Standard Deviation)

Table 3. DQI components according to the adolescents' diet quality awareness and nutritional status

	Diet awareness			
	Low	**Median**	**High**	**P***
Underweight				
DQI-Quality	28.0 (35.4)	38.6 (33.5)	43.4 (33.8)	**0.013**
DQI-Equilibrium	37.8 (9.9)	40.5 (11.1)	44.5 (12.4)	**0.001**
DQI-Diversity	72.0 (14.4)	76.6 (13.3)	79.4 (12.6)	**<0.0001**
DQI-Meal	91.7 (12.1)	94.9 (12.4)	96.5 (8.6)	**0.019**
Normal Weight				
DQI-Quality	35.7 (38.5)	40.9 (34.6)	46.7 (32.7)	**<0.0001**
DQI-Equilibrium	38.6 (10.0)	40.8 (10.4)	43.1 (10.2)	**<0.0001**
DQI-Diversity	70.9 (14.5)	74.1 (14.0)	78.0 (13.2)	**<0.0001**
DQI-Meal	90.0 (14.8)	93.1 (12.3)	94.9 (10.9)	**<0.0001**
Overweight				
DQI-Quality	40.2 (40.1)	50.1 (35.3)	49.3 (36.4)	**0.004**
DQI-Equilibrium	39.1 (10.7)	42.3 (10.5)	42.5 (11.2)	**0.0007**
DQI-Diversity	71.0 (14.8)	72.5 (14.9)	74.5 (15.3)	**0.045**
DQI-Meal	87.6 (16.0)	91.7 (13.5)	91.5 (13.9)	**0.017**
Obese				
DQI-Quality	48.3 (39.5)	54.7 (33.4)	51.8 (32.6)	0.41
DQI-Equilibrium	40.0 (9.6)	44.6 (12.4)	42.3 (10.2)	0.11
DQI-Diversity	70.6 (15.2)	75.0 (16.9)	71.0 (16.0)	0.50
DQI-Meal	90.2 (14.4)	95.4 (10.8)	84.5 (15.0)	0.23

* P for trend adjusted for center using linear mixed effect model (diet awareness level was treated as an ordinal factor).

Values are mean (Standard Deviation)

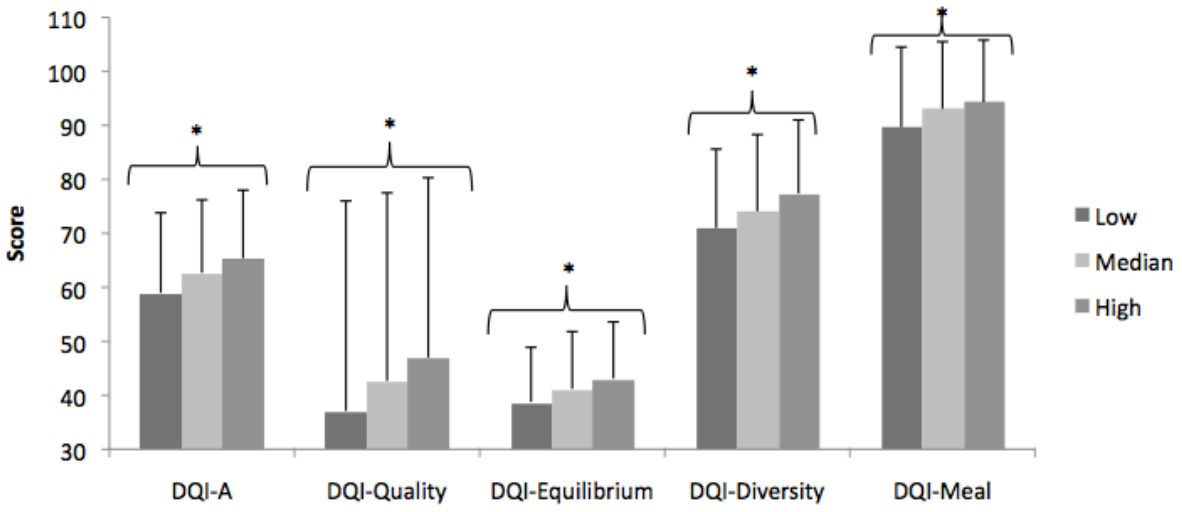

Figure 1. DQI-A according to the adolescents' dietary quality awareness

†DQI-A: Diet Quality Index-Adolescents
* P for trend adjusted for center using linear mixed effect model (diet perception level was treated as an ordinal factor) ($p<0.0001$)
Values are mean (Standard Deviation)