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### ► To cite this version:

Jeremy Vanhelst, Laurent Beghin, Alain Duhamel, Stefaan de Henauw, Jonatan R Ruiz, et al.. Do adolescents accurately evaluate their diet quality? The HELENA study. *Clinical Nutrition*, 2017, 36 (6), pp.1669-1673. 10.1016/j.clnu.2016.10.019 . hal-02176971

**HAL Id: hal-02176971**

**<https://hal.univ-lille.fr/hal-02176971>**

Submitted on 8 Jul 2019

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

2 **Short running head:** adolescents' dietary awareness

3

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35

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

41

## 41 SUMMARY

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

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

52 *Results:* There was a positive association between DQI-A scores and diet quality perception  
53 levels ( $p < 0.0001$ ). The mean DQI-A was 59.0 (SD = 14.8) in adolescents with a low dietary  
54 awareness compared with 65.4 (SD = 12.6) in adolescents with high dietary awareness ( $p <$   
55  $0.0001$ ). Similar results were found for all the DQI components. When analyses were  
56 stratified, we found a significant heterogeneity across the nutritional status, with no  
57 significant association between DQI-A and dietary awareness level in obese adolescents, but a  
58 positive association in overweight, normal and undernourished groups. We found also a  
59 significant heterogeneity associated with the lunch location (school or home). No other factor  
60 affected dietary awareness (gender, pubertal status and maternal educational level).

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

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

## 66 **1. Introduction**

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

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

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

## 85 **2. Methods**

### 86 *2.1 Study design*

87 The Healthy Lifestyle in Europe by Nutrition in Adolescence Cross-Sectional Study  
88 (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<sup>2</sup> (m<sup>2</sup>). 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](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  $\pm$  standard  
134 deviation (SD) for quantitative variables. Normality of distribution was checked graphically  
135 and using the Shapiro–Wilk test.

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

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

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

149

### 150 **3. Results**

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

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



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

#### 171 **4. Discussion**

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

177           Unexpectedly, our main finding was that European adolescents, regardless of gender,  
178 pubertal status, maternal educational level and lunch location, correctly assess their own diet  
179 quality. While adolescents have been shown to have difficulties in qualifying their daily  
180 physical activity (they tend to overestimate their physical activity patterns), our data show that  
181 is not the case for their assessment of diet quality [28]. This probably results from education  
182 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.

222

222           **Funding sources**

223           The authors thank the participants for taking part in the study. The HELENA study is  
224 made possible by the financial support of the European Community Sixth RTD Framework  
225 Programme (Contract FOOD-CT-20056007034) and the Spanish Ministry of Science and  
226 Innovation (RYC-2010-05957). The content of this paper reflects only the authors' views, and  
227 the European Community is not liable for any use that may be made of the information  
228 contained therein.

229

230           **Conflict of interest**

231           The authors do not have any competing interests.

232

233           **Acknowledgements**

234           The authors thank the participants for taking part in the study.

235

236

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369

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

	<b>Included</b>	<b>Not included</b>	<b>P</b>
Number of adolescents	3389	139	
Gender (% <i>boys</i> )	47.4	55.4	0.06
Age ( <i>yr</i> )	14.7 ± 1.2	14.7 ± 1.3	0.69
Nutritional status (% <i>UW</i> /% <i>NW</i> /% <i>OW</i> /% <i>O</i> ) <sup>a</sup>	6.2 / 70.9 / 17.3 / 5.6	3.6 / 67.6 / 22.3 / 6.5	0.09
Pubertal status (% <i>II</i> /% <i>III</i> /% <i>IV</i> /% <i>V</i> ) <sup>b</sup>	6.0 / 22.3 / 42.2 / 29.5	8.0 / 27.0 / 41.0 / 24.0	0.11
Mother education level (% <i>I</i> /% <i>II</i> /% <i>III</i> ) <sup>c</sup>	34.7 / 31.4 / 33.9	47.1 / 30.0 / 22.9	<b>0.02</b>
Place adolescents used to have lunch (% <i>school</i> )	23.8	26.1	0.68
<i>For boys</i>			
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
<i>For girls</i>			
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

<sup>a</sup> Nutritional status: underweight (UW), normal weight (NW), overweight (OW), obese (O)

<sup>b</sup> Pubertal status staging according to Tanner

<sup>c</sup> 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

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

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).

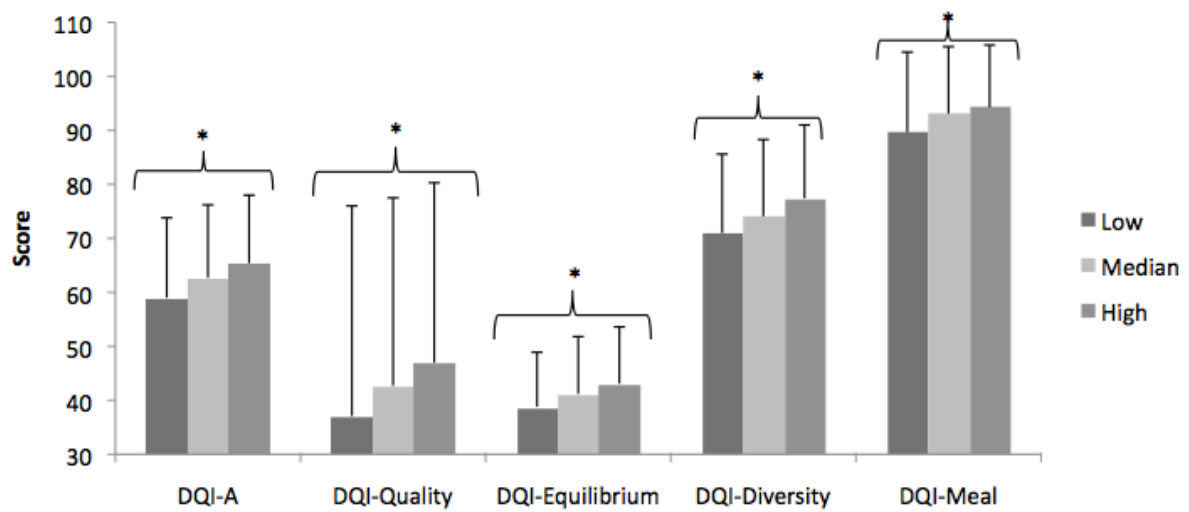
\*\*mean (Standard Deviation)

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

	<b>Diet awareness</b>			
	<b>Low</b>	<b>Median</b>	<b>High</b>	<b>P*</b>
<i>Underweight</i>				
DQI-Quality	28.0 (35.4)	38.6 (33.5)	43.4 (33.8)	<b>0.013</b>
DQI-Equilibrium	37.8 (9.9)	40.5 (11.1)	44.5 (12.4)	<b>0.001</b>
DQI-Diversity	72.0 (14.4)	76.6 (13.3)	79.4 (12.6)	<b>&lt;0.0001</b>
DQI-Meal	91.7 (12.1)	94.9 (12.4)	96.5 (8.6)	<b>0.019</b>
<i>Normal Weight</i>				
DQI-Quality	35.7 (38.5)	40.9 (34.6)	46.7 (32.7)	<b>&lt;0.0001</b>
DQI-Equilibrium	38.6 (10.0)	40.8 (10.4)	43.1 (10.2)	<b>&lt;0.0001</b>
DQI-Diversity	70.9 (14.5)	74.1 (14.0)	78.0 (13.2)	<b>&lt;0.0001</b>
DQI-Meal	90.0 (14.8)	93.1 (12.3)	94.9 (10.9)	<b>&lt;0.0001</b>
<i>Overweight</i>				
DQI-Quality	40.2 (40.1)	50.1 (35.3)	49.3 (36.4)	<b>0.004</b>
DQI-Equilibrium	39.1 (10.7)	42.3 (10.5)	42.5 (11.2)	<b>0.0007</b>
DQI-Diversity	71.0 (14.8)	72.5 (14.9)	74.5 (15.3)	<b>0.045</b>
DQI-Meal	87.6 (16.0)	91.7 (13.5)	91.5 (13.9)	<b>0.017</b>
<i>Obese</i>				
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)