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Healthy Lifestyle in Europe by Nutrition in Adolescence  
(HELENA) study.**

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**Adolescents' diet quality in relation to their relatives' and peers' diet engagement and encouragement: the Healthy Lifestyle in Europe by Nutrition in Adolescence (HELENA) study.**

Jérémy Vanhelst, Laurent Béghin, Elodie Drumez, Alain Duhamel, Stefaan De Henauw, Jonatan R Ruiz, Anthony Kafatos, Yannis Manios, Kurt Widhalm, Béatrice Mauro, Michael Sjöström, Mathilde Kersting, Frédéric Gottrand.

**1 ABSTRACT**

2 **Objectives:** To examine the associations between adolescents' diet quality and their  
3 perceived relatives' and peers' diet engagement and encouragement.

4 **Design:** Cross-sectional study performed in European countries. Diet quality was scored  
5 using the Diet Quality Index for Adolescents (DQI-A) based on four components: quality,  
6 diversity, balance, and meal frequency. Perceived diet quality engagement and perceived  
7 encouragement of the relatives/peers were assessed using the questions, "How healthy is each  
8 of the following persons' diet?" and "How often does each of the following persons  
9 encourage you to eat a healthy diet?"

10 **Setting:** Vienna, Ghent, Lille, Athens, Heraklion, Pecs, Rome, Dortmund, Zaragoza, and  
11 Stockholm.

12 **Subjects:** 2943 healthy adolescents.

13 **Results:** The perceived engagement level of the mother, father and sister were positively  
14 associated with the DQI-A ( $P < 0.05$ ). A positive association was found for the perceived  
15 engagement level of siblings, father and mother with all specific components ( $P < 0.05$ ). DQI-  
16 A was negatively associated with the perceived encouragement level from a best friend and  
17 positively associated with the encouragement level of the mother and father ( $P < 0.05$ ).  
18 Diversity, balance and quality components were positively associated with the perceived  
19 encouragement level from the mother and father ( $P < 0.05$ ), whereas the best friend's  
20 perceived encouragement was negatively associated with meal frequency components ( $P <$   
21  $0.01$ ).

22 **Conclusions:** These findings highlight the role of social engagement and encouragement of  
23 relatives and peers in adolescents' diet quality. Intervention or promotion programs aimed at  
24 enhancing diet quality in adolescents should target both family and peers.

25

26 **Keywords:** Youth; Assessment; Nutrition; Family; Epidemiological study

27

28

## 1 **Introduction**

2 Adolescence is an important period in life that includes multiple physiological and  
3 psychological changes that have a considerable effect on dietary habits <sup>(1-2)</sup>. Unhealthy food  
4 consumption patterns during childhood and adolescence are linked with both the occurrence  
5 of obesity in youth and the later risk of developing diseases such as cancer, obesity, and  
6 cardiovascular diseases in adulthood <sup>(3)</sup>.

7 Dietary habits are influenced by individual, social, and environmental factors, including  
8 food choice decisions, food choice motivations, religious adherence, food cravings, taste,  
9 hunger, time and effort required for food preparation and consumption, cost, body image, and  
10 socioeconomic status <sup>(4-8)</sup>. Dietary habits are also influenced by cultural traditions, which  
11 differ between countries <sup>(9-10)</sup>. Family and peers are considered to be important sociocultural  
12 influences that have a strong impact on dietary habits during adolescence <sup>(11-17)</sup>. Previous  
13 studies have consistently demonstrated the importance of parents to healthy eating habits  
14 during adolescence, specifically vegetable and fruit consumption <sup>(13, 16, 17)</sup>. Previous studies of  
15 both encouragement and engagement have also found that friends influence the intake of  
16 healthy foods, such as vegetables, energy drinks, snacks, desserts, fruits, whole grains, and  
17 biscuits <sup>(13-15)</sup>. However, previous studies have not included the influence of siblings'  
18 encouragement and engagement in terms of the diet. Moreover, the aim of previous research  
19 was to compare the social influence of parents and friends on eating attitudes of adolescents  
20 by focusing specifically on particular food groups <sup>(11-17)</sup>. To our knowledge, no previous  
21 studies have examined the influence of family and peers on the diet quality taking account  
22 into quality, diversity, equilibrium and meal frequency in adolescents.

23 Therefore, the aim of this study was to examine the associations between adolescents'  
24 diet quality and their perceived relatives' and peers' (father, mother, brothers, sisters, and best  
25 friend) diet engagement and encouragement.

26

## 27 **Methods**

### 28 *Study design*

29 This was a secondary data analysis of the Healthy Lifestyle in Europe by Nutrition in  
30 Adolescence (HELENA) Study ([www.helenastudy.com](http://www.helenastudy.com)) performed in European adolescents  
31 (2006-2007). The aim of the HELENA Study was to obtain a broad range of standardized,  
32 reliable, and comparable nutrition- and health-related data from a random sample of European  
33 adolescents aged 12.5-17.5 years.

34

1 The random selection of schools and classes was performed centrally. The first step of the  
2 recruitment strategy consisted of phone contact with the director/principal of the school.  
3 During the call, a meeting with the director/principal and main/principal teachers of selected  
4 classes was organized to present the study aims and procedures and obtain consent to  
5 participate. The second step consisted of a meeting with adolescents from selected classes and  
6 their main/principal teacher. During this meeting, the study aims, procedures, and tests were  
7 explained. Information and consent forms were then distributed, and the adolescents were  
8 asked to return the written/signed consent form (including the signatures of the adolescent and  
9 both parents) within a maximum of 2 weeks after the meeting. Table 1 presents an overview  
10 of the participation rate of the different sampling units for the whole study and for each center  
11 individually. In total, 3528 adolescents were included in the HELENA Study, 83% of whom  
12 completed the dietary habits questionnaire and were therefore included in the present study.  
13 The participants' characteristics are presented in Table 2. No significant differences were  
14 observed between the included and excluded adolescents' characteristics.

15 The local ethics committee for each country approved the HELENA study, and all  
16 procedures were performed in accordance with the ethical standards of the Helsinki  
17 Declaration of 1975, as revised in 2008, and the European Good Clinical Practices.

18  
19

## 20 **Measurements**

### 21 *Assessment of relatives' diet engagement and encouragement*

22 A self-administrated questionnaire was used to assess healthy diet determinants. A paper  
23 version of the questionnaire was administrated in a classroom under the supervision of a  
24 HELENA fieldworker. Two questions on engagement and encouragement were extracted for  
25 the present study<sup>(18)</sup>. The adolescents were asked about the perceived diet quality engagement  
26 of their relatives and peers (father, mother, brother(s), sister(s), and best friend(s) using the  
27 following question: "How healthy is each of the following persons' diet: (father, mother,  
28 sister(s), brother(s), best friend(s))?" The adolescents' perceived engagement of their relatives  
29 and peers was classified as low if the answer to the question was "very unhealthy" or "not  
30 very healthy," medium if "average" or "quite healthy," and high if "very healthy." The  
31 adolescents were also asked about the perceived diet encouragement provided by their  
32 relatives and peers using the following question: "How often does each of the following  
33 persons encourage you to eat a healthy diet: (father, mother, sister(s), brother(s), best  
34 friend(s))?" The answers were classified as low if the answer to the question was "not at all"

1 or ‘not much,’ medium if “sometimes” or “often,” and high if “very often”. These questions  
2 regarding perceived relatives’ diet engagement and encouragement were extracted from a  
3 healthy diet determinants questionnaire that has been found to be valid and reliable <sup>(18)</sup>.

#### 5 *Dietary habits*

6 Dietary intake was assessed by two non-consecutive 24-h recalls performed on two  
7 convenient weekdays 1 week apart. The 24-h recalls were recorded using the self-  
8 administered, computer-based HELENA Dietary Intake Assessment Tool (HELENA-DIAT),  
9 which has been validated in European adolescents <sup>(19)</sup>. The HELENA-DIAT tool is based on  
10 intake assessments at six meal occasions (breakfast, morning snack, lunch, afternoon snack,  
11 evening meal, and evening snack) on the previous day. Trained dietitians assisted the  
12 adolescents to complete the 24-h recalls when needed. To calculate energy and nutrient  
13 intakes, data from HELENA-DIAT were linked to the German Food Code and Nutrient  
14 Database (*Bundeslebensmittelschlüssel*, version II.3.1) <sup>(20)</sup>. The Multiple Source Method was  
15 used to estimate the usual energy, nutrient, and food intakes.

16 The DQI-A is composed of four components—quality, diversity, equilibrium, and meal  
17 frequency—that were previously validated in the HELENA population <sup>(21–24)</sup>. Daily diet was  
18 divided into nine recommended food groups: (1) water, (2) bread and cereal, (3) potatoes and  
19 grains, (4) vegetables, (5) fruits, (6) milk products, (7) cheese, (8) meat, fish, and substitutes,  
20 and (9) fats and oils. Dietary quality indicated whether an adolescent made optimal food  
21 quality choices within a food group and was represented by a ‘preference group’ (i.e., the  
22 healthiest foods: cereal/brown bread, fresh fruit, and fish), an ‘intermediate group’ (e.g., white  
23 bread, minced meat), and a ‘low-nutrient, energy-dense group’ (i.e., the unhealthiest foods:  
24 soft drinks, sweet snacks, and chicken nuggets) using predefined criteria. The dietary quality  
25 score was then calculated by multiplying the amount of the food (in g) consumed with a  
26 weighing factor (+1 for the preference group, 0 for the intermediate group and –1 for the low-  
27 nutrient, energy-dense group) divided by the total amount of food (in g). The diet quality  
28 score was expressed as a percentage, meaning that it could vary between –100 and 100%. The  
29 diversity component corresponds to the degree of variation in the diet. The score was obtained  
30 by assigning 1 point for each food group that had at least one serving at the preference level,  
31 divided by 9 (which represents the maximum score), and then expressed as a percentage  
32 between 0 and 100%. Dietary equilibrium was calculated as the difference between the  
33 adequacy component (the percentage of food groups with intake above the minimum  
34 recommended value) and the excess component (the percentage of food groups exceeding the

1 upper level of the recommended intake) and ranged between 0 and 100%. Meal frequency  
2 was scored as 0 when no food was consumed and 1 when some food was consumed at each of  
3 the three main meal occasions. The scores for the three occasions were summed and  
4 expressed as a percentage; the possible scores were thus 0% (no consumption at any of the  
5 main meals), 33% (consumption at only one main meal), 66% (consumption at two main  
6 meals), and 100% (consumption at all three main meals).

7 The four DQI-A components are presented as percentages. The quality component ranged  
8 from -100% to 100%, whereas diversity, equilibrium, and meal ranged from 0% to 100%.  
9 The DQI-A was computed as the arithmetic mean of these four components; hence, the DQI-  
10 A ranged from -25% to 100%, with higher scores reflecting a higher-quality diet. The score  
11 was calculated for each day and the mean daily score was taken as the individual's overall  
12 index.

13

#### 14 *Participants' characteristics*

15 Body weight was measured with the participant wearing light clothes and without shoes  
16 to the nearest 0.1 kg using an electronic scale (SECA 871; SECA, Hamburg, Germany).  
17 Height was measured without shoes to the nearest 0.1 cm using a telescopic height-measuring  
18 instrument (SECA 225; SECA). Body mass index (BMI) was calculated as weight  
19 (kg)/height<sup>2</sup> (m<sup>2</sup>). The nutritional status was assessed using the International Obesity Task  
20 Force scale<sup>(25)</sup>. An extended and detailed manual of operations was designed for and  
21 thoroughly read by every researcher involved in fieldwork before the data collection started  
22 (Nagy et al., 2008). In addition, a workshop training week was carried out before the study  
23 began to standardize and harmonize the data collect methods. The instructions given to the  
24 participants for every measurement were standardized for all cities and translated into the  
25 local language.

26 Parental educational level was classified into one of four categories using a specific  
27 questionnaire adapted from the International Standard Classification of Education (ISCED)  
28 (<http://www.uis.unesco.org/Library/Documents/isced97-en.pdf>). Parental educational level  
29 was scored as 1 for primary and lower education (levels 0, 1, and 2 in the ISCED  
30 classification); 2 for higher secondary (levels 3 and 4 in the ISCED classification); and 3 for  
31 tertiary (levels 5 and 6 in the ISCED classification).

32

#### 33 **Statistical analysis**

1 The data are presented as percentages for qualitative variables and mean  $\pm$  SD for  
2 quantitative variables. Normality of distribution was checked graphically and by using the  
3 Shapiro–Wilk test.

4 To assess the potential bias related to missing or incomplete data for the DQI-A, the main  
5 adolescent characteristics were compared between adolescents with and without DQI-A data  
6 using Student’s *t* test for quantitative variables, the chi-square test for categorical variables,  
7 and the Mantel–Haenszel trend test for ordered categorical variables (Table 1)..

8 We examined the association between the oDQI-A (overall index and each component)  
9 and each perceived relative’s and peer’s diet and encouragement levels using linear mixed  
10 models adjusted for prespecified confounding factors, including age, sex, and parental  
11 educational level as fixed effects, and city, city\*school, and city\*school\*class as random  
12 effects <sup>(21,26–27)</sup>. The adjusted means for the DQI-A  $\pm$  SEM were calculated using the least-  
13 square means. Because the perceived relatives’ diet or encouragement levels were classified  
14 into three ordered levels, we used linear contrasts to perform trend test. Comparisons of  
15 overall DQI-A between the 10 perceived relatives’ diet or encouragement levels (main  
16 objective) were adjusted for multiple comparisons using the false discovery rate controlling  
17 method <sup>(28)</sup>.

18 To avoid case deletion in the analyses, missing data were imputed by multiple  
19 imputations using the regression-switching approach (chained equations with  $m = 20$   
20 imputations obtained using R statistical software, version 3.03) <sup>(29)</sup>. The imputation procedure  
21 was performed under the missing-at-random assumption using all adolescents’ characteristics,  
22 relatives’ and peers’ diet engagement and encouragement, DQI components with the  
23 predictive mean-matching method for quantitative variables, logistic regression model for  
24 binary variables, and ordinal logistic regression for ordered categorical variables. Rubin’s  
25 rules were used to combine the estimates derived from multiple imputed data sets <sup>(30)</sup>. We  
26 performed a key subgroup analysis according to sex for the associations of overall DQI-A and  
27 meal frequency component with each perceived relative’s diet and encouragement levels.  
28 Inclusion of the corresponding interaction term into the multivariable linear mixed model was  
29 used to assess heterogeneity.

30 All statistical tests were done at the two-tailed  $\alpha$  level of  $P < 0.05$ . Data were analyzed  
31 using SAS software (version 9.3; SAS Institute Inc., Cary, NC).

### 33 Results

34 Physical characteristics of subjects are presented in Table 1.

1 The adolescents' DQI-A score was positively and significantly associated with their  
2 perceived mother's, brother's, and sister's diet engagement (Table 3). Having a high level of  
3 perceived mother's, brother's, and sister's engagement resulted in 6%, 5%, and 4% higher  
4 diet quality scores, respectively, compared with the low level (Table 3). We found also  
5 significant positive associations between perceived sister's diet engagement and the  
6 adolescents' quality component ( $39.5 \pm 2.8$  vs.  $43.2 \pm 1.8$  vs.  $48.1 \pm 2.6$  for low, medium, and  
7 high, respectively;  $P = 0.004$ ; + 21.7%) (Fig. 1). Similarly, a significant positive association  
8 was observed between perceived brother's diet engagement and the diversity component ( $72.4$   
9  $\pm 1.1$  vs.  $73.9 \pm 0.9$  vs.  $76.2 \pm 1.3$  for low, medium, and high, respectively;  $P = 0.003$ ; +  
10 5.2%), perceived father's diet engagement and the balance ( $40.1 \pm 0.6$  vs.  $41.0 \pm 0.3$  vs.  $41.5$   
11  $\pm 0.5$  for low, medium, and high, respectively;  $P = 0.047$ ; + 3.5%) and diversity components  
12 ( $72.7 \pm 1.1$  vs.  $73.6 \pm 0.9$  vs.  $75.1 \pm 1.1$  for low, medium, and high, respectively;  $P = 0.003$ ;  
13 +3.3%), and between perceived mother's diet engagement and the balance ( $39.3 \pm 0.9$  vs.  $40.8$   
14  $\pm 0.3$  vs.  $41.9 \pm 0.4$  for low, medium, and high, respectively;  $P = 0.005$ ; + 6.6%) (Fig. 1).  
15 Similar findings were observed for the diversity ( $71.2 \pm 1.4$  vs.  $73.4 \pm 0.9$  vs.  $75.3 \pm 0.9$  for  
16 low, medium, and high, respectively;  $P = 0.005$ ; + 5.7%) and meal components ( $89.8 \pm 1.0$  vs.  
17  $91.7 \pm 0.7$  vs.  $92.6 \pm 0.8$  for low, medium, and high, respectively;  $P = 0.023$ ; + 3.1%) (Fig. 1).

18 The DQI-A score was significantly negatively associated with the perceived best friend's  
19 encouragement and positively associated with the perceived father's and mother's  
20 encouragement (Table 4). Having a high level of perceived best friend's father's and mother's  
21 encouragement resulted in 4%, 4.4%, and 4.4% higher diet quality scores, respectively,  
22 compared with the low level (Table 4). The perceived father's encouragement level was  
23 positively and significantly associated with the quality, diversity, and balance components  
24 (Fig. 2). The differences observed in the diet quality score between the low and high levels of  
25 perceived father's encouragement were 13.4%, 3.9%, and 3.2% for the quality, diversity, and  
26 balance components, respectively (Fig. 2). Positive associations were also found between the  
27 perceived mother's encouragement and the quality, balance, and diversity components.  
28 Differences observed in the diet quality score between the low and high levels of perceived  
29 mother's encouragement were 13%, 4%, and 5.5% for the quality, balance, and diversity  
30 components, respectively (Fig. 2). Another positive association was found between the  
31 perceived sister's diet encouragement and the balance component with a difference of 4.6% in  
32 diet quality score between the low and high perceived encouragement levels (Fig. 2). The  
33 perceived best friend's encouragement was negatively associated with the meal component



1 with a difference of 3.7% in the diet quality score between the low and high perceived  
2 encouragement levels (Fig. 2).

3 The association between adolescents' DQI-A and perceived mother's diet encouragement  
4 was stronger in boys than in girls, although the heterogeneity test did not reach the level of  
5 significance ( $P$  for heterogeneity = 0.089). In boys, the adjusted mean DQI  $\pm$  SEM was  $58.8 \pm$   
6  $1.1$  vs.  $61.0 \pm 0.9$  vs.  $62.2 \pm 1.1$  for the low, medium, and high perceived mother's diet  
7 encouragement levels, respectively ( $P$  for trend = 0.002). By contrast, in girls, the adjusted  
8 mean DQI  $\pm$  SEM was  $63.1 \pm 1.1$  vs.  $64.1 \pm 0.8$  vs.  $64.7 \pm 0.8$  for the low, medium, and high  
9 perceived mother's diet encouragement levels, respectively ( $P$  for trend = 0.12). We found no  
10 other significant heterogeneity based on the adolescents' sex (data not shown).

11  
12

### 13 Discussion

14 Our study aimed to investigate the associations between adolescents' diet and their  
15 perceived relatives' and peers' (father, mother, brothers, sisters, and best friends) diet  
16 engagement and encouragement. Since our study directly addressed adolescents, we only have  
17 information about perceived engagement and encouragement; relatives' and peers'  
18 engagement and encouragement were not directly assessed. Although we acknowledge that  
19 this could have influenced our results, we believe that adolescents' perceptions influenced  
20 their own diet quality more than relatives' or peers' engagement and encouragement.

21 The main finding of our study is that both perceived relatives' diet engagement and  
22 encouragement were associated with the diet quality of the adolescents studied. However, the  
23 magnitude of the associations with the adolescents' DQI-A scores varied according to the  
24 perceived parent's, family's, or peer's diet engagement and encouragement. A strong positive  
25 association between the perceived mother's diet engagement and the adolescents' diet quality  
26 was found. This shows that mothers play a key role in family food choices, including  
27 adolescents' choices<sup>(31-32)</sup>. This is consistent with previous studies showing the importance of  
28 mothers to adolescents' meals<sup>(33)</sup>. This finding also confirms that the perceived mother's  
29 engagement is associated with adolescents' diet quality. This finding also concurs with  
30 previous studies showing that mother-adolescent communication is more effective than  
31 father-adolescent communication in changing adolescents' nutritional behavior<sup>(34-35)</sup>. Our  
32 finding is also consistent with the results of the Healthy Eating Questionnaire, which showed  
33 that the mother is the family member most likely to promote healthy dietary habits<sup>(36)</sup>.  
34 However, we also found an association between perceived fathers' encouragement and

1 adolescents' diet quality. No previous studies have assessed the influence of brothers and  
2 sisters, and our data show for the first time a positive relationship between their perceived diet  
3 engagement or encouragement and adolescents' diet quality, balance, and diversity  
4 components. This outcome shows the importance of siblings on the diet quality of the  
5 adolescent. Therefore, this is suggest that intervention programs that aim to enhance diet  
6 quality in adolescent populations might be more successful if parents and siblings are also  
7 included in the intervention. Our results concur with previous published studies showing that  
8 youth diet behaviors, particularly in obese pediatric patients, may be improved when parents  
9 attend and are directly involved with services and are provided with training in the skills  
10 required to support lifestyle modifications in accordance with expert guidelines <sup>(37-40)</sup>. In this  
11 context and from a practical point of view, primary care may play a major role in the  
12 improvement of parenting behaviors linked to child health <sup>(41,42)</sup>. Indeed, children and  
13 adolescents, most of the time accompanied by their parents, regularly access primary care  
14 where specialists or generalist physicians are present. Even if health care providers report  
15 having inadequate time and a lack of expertise and resources to effectively work with parents  
16 and provide key messages regarding a healthy lifestyle, attempting to implement a specific  
17 time for discussion with parents and siblings during primary care visits remains important <sup>(43)</sup>.  
18 This point of view is supported by several committees' recommendations regarding the  
19 prevention and treatment of youth overweight and obesity and the promotion of family-  
20 centered interventions in primary care <sup>(44,45)</sup>. Caregivers' policies should be discussed and new  
21 ways to address child and family care should be created for care providers such as  
22 pediatricians, family physicians, nurse practitioners, and physicians' assistants. Concerning  
23 the roles of siblings, few **existing preventive interventions target sibling relationships** <sup>(46)</sup>.  
24 **Therefore, clinicians should also consider offering specific sessions for siblings that focus on**  
25 **healthy eating habits and instruction regarding how to promote and reinforce these habits**  
26 **among their siblings.**

27 Most of the previous studies of the influence of relatives and peers have focused on the  
28 dietary behaviors of girls, and few studies have also included boys <sup>(47-48)</sup>. A significant  
29 difference between girls and boys was found only for the association between adolescents'  
30 DQI-A score and perceived mother's diet encouragement. In contrast to the results of  
31 previous studies of dietary behaviors, we found that girls' diet quality did not correlate with  
32 the perceived mother's diet encouragement <sup>(47)</sup>. Indeed, it has been shown that weight control  
33 behaviors among young girls are modeled partially on their mothers' behaviors <sup>(47,49,50)</sup>. In the  
34 present study, we focused on diet quality components, but not directly on weight control.

1        During the transition from childhood to adolescence, children decrease the time spent  
2 with parents, and spend more time alone and/or with friends <sup>(48)</sup>. One unexpected finding of  
3 our study is the negative association between perceived encouragement of peers to eat  
4 healthily and adolescent unhealthy food consumption. This also contrasts with a recent study  
5 showing that friends' unhealthy food consumption was associated with an individual's  
6 unhealthy food consumption, although that study examined consumption rather than  
7 encouragement <sup>(51)</sup>. One possible explanation is that those adolescents with unhealthy food  
8 consumption are encouraged by their peers to eat more healthily, independently of their peers'  
9 food consumption habits. Differences in our study in the associations between the  
10 adolescents' DQI-A scores and the perceived relatives (positive association) and perceived  
11 peers (negative association) diet engagement might reflect a better awareness of healthy  
12 lifestyle in adults than in adolescents. However, the influence of the relatives may have also  
13 had adverse effects in the medium term <sup>(52)</sup>. Indeed, if perceived relatives' engagement or  
14 encouragement is too important, it could lead to eating disorders and have a negative impact  
15 on future health. Several studies have highlighted concerns about the effectiveness of their  
16 role in dieting and the potential for increasing the risk of unintentional weight gain, disordered  
17 eating, and eating disorders <sup>(52-57)</sup>.

18        The strengths of the study are the large sample size of adolescents with sex-specific  
19 information in 10 European cities, the use of standardized procedures, the inclusion of many  
20 confounding factors in the analyses, and the strong methodology for assessing dietary habits  
21 <sup>(58)</sup>. The limitations of the study include the cross-sectional and observational design to  
22 examine the associations, which cannot be interpreted to reflect causal relationships. The  
23 proxy report of the parent's, family's, and peer's diet engagement and encouragement is  
24 another limitation that could lead to misclassification. Moreover, we cannot rule out bias  
25 because of the estimated values for missing data, as the multiple-imputation procedure to  
26 replace missing values with a set of plausible values was done under a missing-at-random  
27 assumption. Finally, in the present study, we found that the mean differences between  
28 variables was low, which raises the question of their clinical significance..

29        In conclusion, our findings highlight the role of social encouragement and engagement in  
30 adolescents' diet quality. Implementing intervention or promotion programs that aim to  
31 encourage a healthy diet in adolescents might be more successful if the family and peers are  
32 also targeted. Indeed, interventions aimed at improving diet quality in young people might be  
33 more successful when family members are also encouraged to engage in healthy diet quality  
34 and support adolescents' diet quality. Another important point is the fact that adolescents'

1 perceptions of their peers'/families' engagement/encouragement may also play a major role in  
2 their dietary quality and should be addressed in intervention programs focusing on  
3 adolescents.

4

5

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**1 Legends**

2 **Figure 1.** Adolescent's diet components, measured by the HELENA-Diat, according to  
3 relatives' and peers' diet engagement

4 **Figure 2.** Adolescent's diet components, measured by the HELENA-Diat, according to  
5 relatives' and peers' encouragement

**Table 1.** Number of approached/participating classes and adolescents in the HELENA study<sup>†</sup>

| <b>Centers</b>  | <b>Athens</b> | <b>Dortmund</b> | <b>Gent</b> | <b>Heraklion</b> | <b>Lille</b> | <b>Pecs</b> | <b>Roma</b> | <b>Stockholm</b> | <b>Vienna</b> | <b>Zaragoza</b> |
|---|---------------|-----------------|-------------|------------------|--------------|-------------|-------------|------------------|---------------|-----------------|
| Number of eligible schools in the city  | 82            | 55              | 43          | 22               | 40           | 12          | 290         | 25               | 347           | 83              |
| Number of schools approached/participating  | 17/10         | 14/11           | 11/9        | 11/10            | 13/12        | 8/7         | 18/10       | 14/10            | 23/13         | 16/12           |
| Number of classes approached/participating  | 14/14         | 23/23           | 20/19       | 22/20            | 19/18        | 24/14       | 24/22       | 25/23            | 35/19         | 26/23           |
| Number of adolescents approached in all approached classes                              | 458           | 603             | 429         | 429              | 538          | 720         | 420         | 645              | 870           | 597             |
| Number of adolescents approached in all participating classes/adolescents participating | 458/370       | 603/515         | 413/347     | 400/340          | 508/308      | 420/401     | 430/339     | 535/377          | 536/427       | 537/441         |
| Number of adolescents included in HELENA Study  | 321 (70%)*    | 476 (79%)*      | 336 (78%)*  | 284 (66%)*       | 287 (53%)*   | 394 (55%)*  | 304 (65%)*  | 341 (53%)*       | 403 (63%)*    | 382 (64%)*      |

<sup>†</sup> data collected from 2006 to 2007

\* Percentage calculated to reflect ratio of selected adolescents for statistical analysis to adolescents approached in all approached classes

3

4

**Table 2.** Characteristics of the population

|   | Before imputation |                     | After imputation  |
|---|-------------------|---------------------|-------------------|
|   | Without missing   | With missing        |                   |
|   | DQI-A             | DQI-A               |                   |
| N   | 2943              | 585                 | 3528              |
| Sex (%M)  | 47.2              | 50.3                | 47.7              |
| Age (yr)  | 14.8 ± 1.2        | 14.5 ± 1.2 *        | 14.7 ± 1.2        |
| Height (cm)                                       | 166.2 ± 9.2       | 163.8 ± 8.7 *       | 165.8 ± 9.1       |
| Body mass (kg)                                    | 59 ± 12.7         | 59.9 ± 12.9         | 59.1 ± 12.7       |
| Z-score BMI                                       | 0.32 ± 0.9        | 0.62 ± 0.9 *        | 0.37 ± 0.9        |
| Nutritional status (%UW/%NW/%OW/%O) <sup>a</sup>  | 6.7/72/16.4/4.9   | 3.1/64.6/22.9/9.4 * | 6.1/70.8/17.5/5.6 |
| Father education level (%I/%II/%III) <sup>b</sup> | 37.4/27/35.6      | 39.9/32/28.1 *      | 38.7/27.5/33.8    |
| Mother education level (%I/%II/%III) <sup>b</sup> | 34/30.9/35.1      | 40.2/33.9/25.9 *    | 35.5/31.0/33.5    |

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

2 <sup>b</sup> Education level: lower education (I); higher secondary education (II); higher education or university  
3 degree (III).

4 \* p<0.05 for comparison between the two samples, without and with missing data on DQI-A.

1

**Table 3.** DQI-A according to their relatives' and peers' diet engagement

| <b>Relatives</b>   | <b>Diet engagement</b> | <b>N</b> | <b>Mean DQI-A (SEM)</b> | <b>P*</b>    |
|--------------------|------------------------|----------|-------------------------|--------------|
| <i>Father</i>      |                        |          |                         |              |
|                    | Low                    | 475      | 62.07 (0.98)            |              |
|                    | Medium                 | 2447     | 62.21 (0.68)            | 0.077        |
|                    | High                   | 606      | 63.92 (0.84)            |              |
| <i>Mother</i>      |                        |          |                         |              |
|                    | Low                    | 203      | 60.13 (1.27)            |              |
|                    | Medium                 | 2413     | 62.21 (0.67)            | <b>0.008</b> |
|                    | High                   | 912      | 63.74 (0.77)            |              |
| <i>Brother</i>     |                        |          |                         |              |
|                    | Low                    | 757      | 61.84 (0.81)            |              |
|                    | Medium                 | 2443     | 62.36 (0.68)            | <b>0.008</b> |
|                    | High                   | 328      | 64.93 (1.06)            |              |
| <i>Sister</i>      |                        |          |                         |              |
|                    | Low                    | 458      | 61.03 (1.00)            |              |
|                    | Medium                 | 2622     | 62.53 (0.67)            | <b>0.032</b> |
|                    | High                   | 448      | 63.45 (0.99)            |              |
| <i>Best friend</i> |                        |          |                         |              |
|                    | Low                    | 612      | 62.01 (0.86)            |              |
|                    | Medium                 | 2651     | 62.75 (0.67)            | 0.36         |
|                    | High                   | 265      | 60.98 (1.16)            |              |

2

Number, adjusted mean (SEM) and P-value for trend across relatives' diet engagement were calculated using linear mixed models including age, sex, and parental educational level as fixed effects and city, city\*school and city\*school\*class as a random effects after handling missing data by multiple imputation.

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\* controlled for multiple comparisons using the false discovery rate method.

7

**Table 4.** DQI-A according to their relatives' and peers' diet encouragement

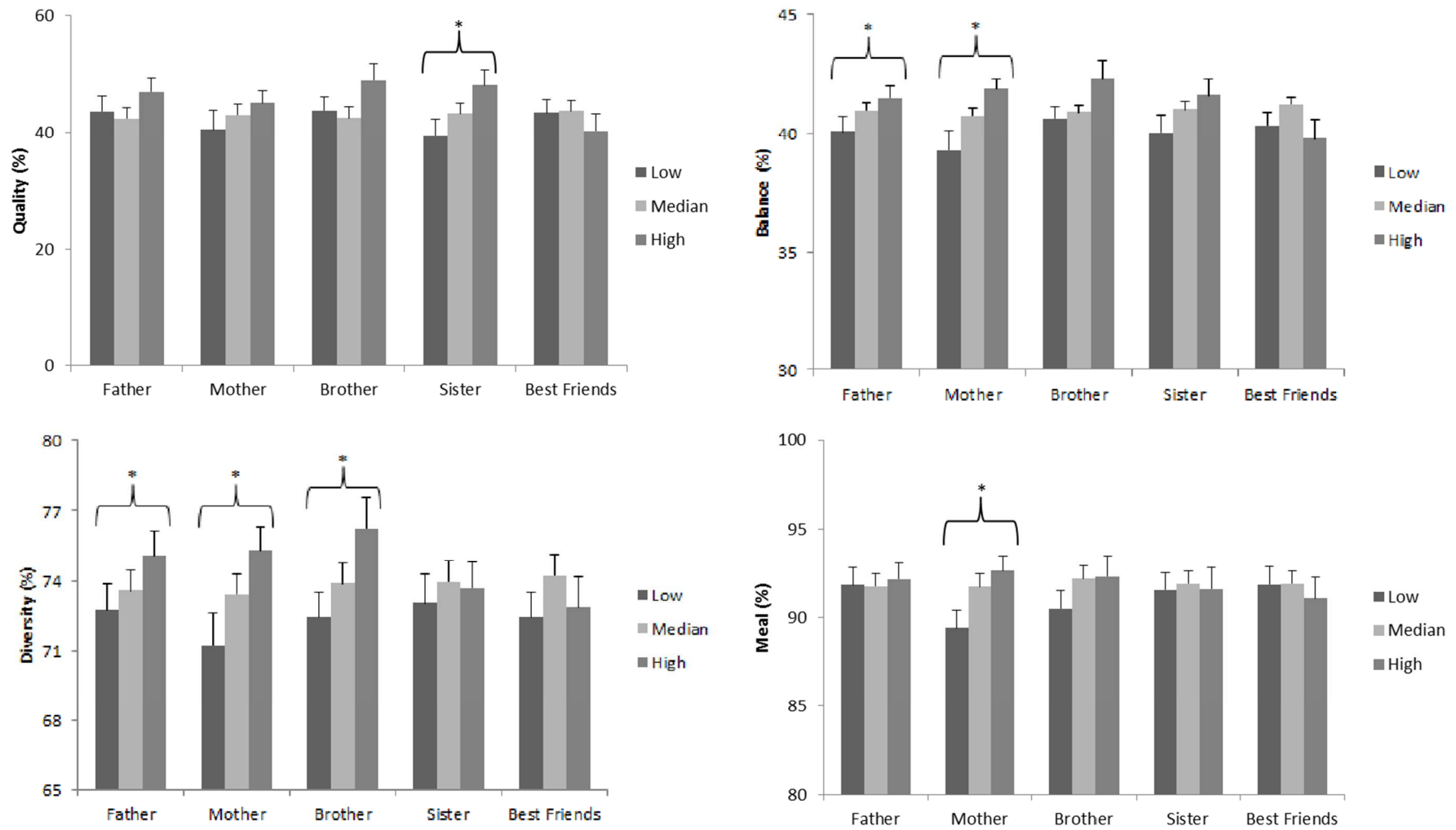
| <b>Relatives</b>   | <b>Diet encouragement</b> | <b>N</b> | <b>Mean DQI-A (SEM)</b> | <b>P*</b>        |
|--------------------|---------------------------|----------|-------------------------|------------------|
| <i>Father</i>      |                           |          |                         |                  |
|                    | Low                       | 1097     | 61.52 (0.73)            |                  |
|                    | Medium                    | 1791     | 62.46 (0.68)            | <b>&lt;0.001</b> |
|                    | High                      | 640      | 64.23 (0.87)            |                  |
| <i>Mother</i>      |                           |          |                         |                  |
|                    | Low                       | 612      | 60.77 (0.82)            |                  |
|                    | Medium                    | 1865     | 62.50 (0.67)            | <b>&lt;0.001</b> |
|                    | High                      | 1051     | 63.46 (0.75)            |                  |
| <i>Brother</i>     |                           |          |                         |                  |
|                    | Low                       | 2412     | 62.46 (0.68)            |                  |
|                    | Medium                    | 893      | 62.18 (0.79)            | 0.23             |
|                    | High                      | 223      | 64.10 (1.34)            |                  |
| <i>Sister</i>      |                           |          |                         |                  |
|                    | Low                       | 2194     | 62.10 (0.67)            |                  |
|                    | Medium                    | 1030     | 63.10 (0.79)            | 0.32             |
|                    | High                      | 304      | 63.36 (1.26)            |                  |
| <i>Best friend</i> |                           |          |                         |                  |
|                    | Low                       | 2235     | 62.71 (0.69)            |                  |
|                    | Medium                    | 1069     | 62.51 (0.78)            | <b>0.040</b>     |
|                    | High                      | 224      | 60.20 (1.25)            |                  |

1 Number, adjusted mean (SEM) and P-value for trend across relatives' diet engagement were  
2 calculated using linear mixed models including age, sex, and parental educational level as fixed  
3 effects and city, city\*school and city\*school\*class as a random effects after handling missing  
4 data by multiple imputation.

5 \* controlled for multiple comparisons using the false discovery rate method

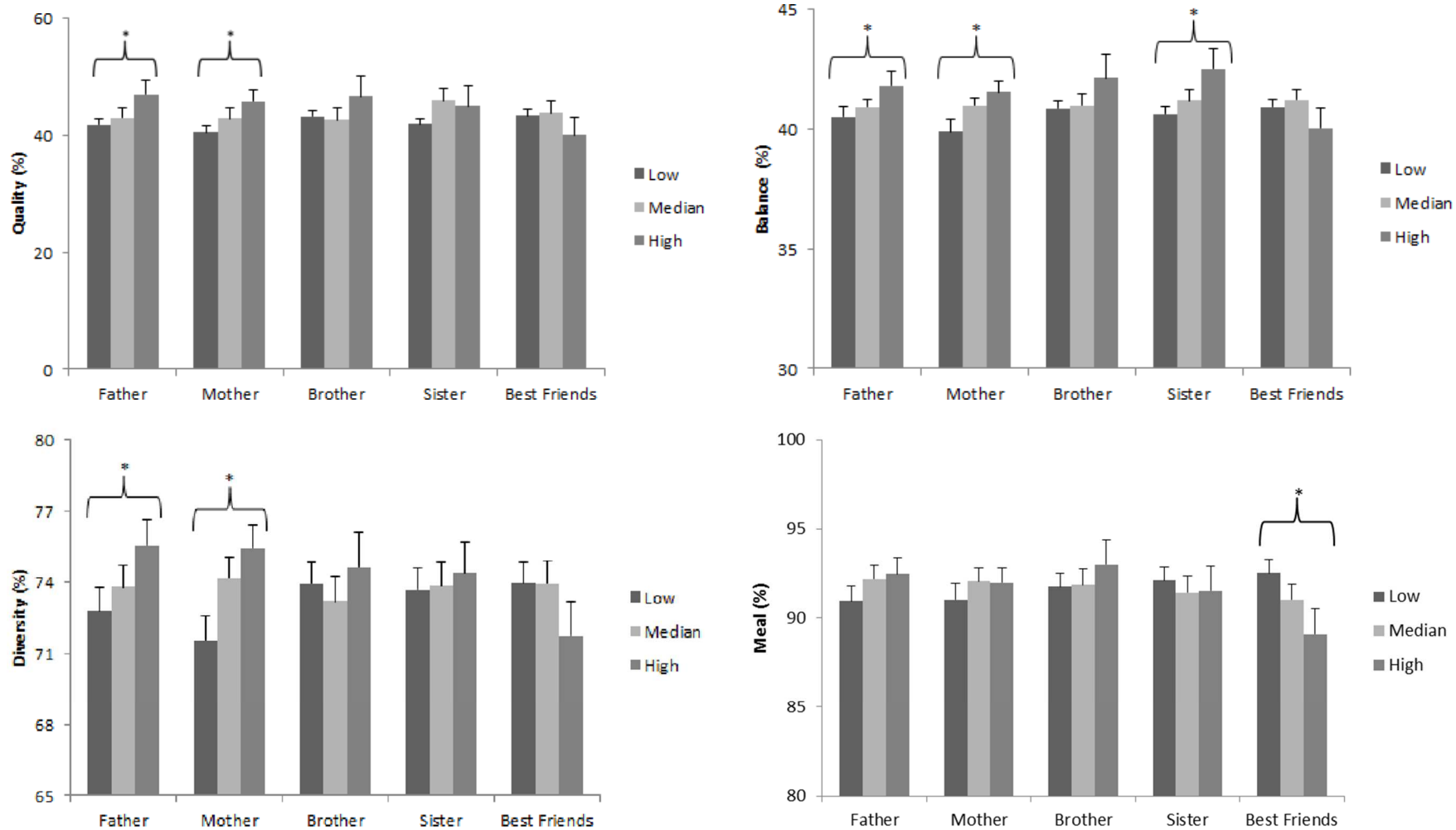
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7



**Figure 1.** Adolescent's diet components measured by the HELENA-Diat, according to their relatives' and peers' diet engagement. Values are mean (SEM) of each component, calculated using linear mixed models including age, sex, and parental educational level as fixed effects and city, city\*school and city\*school\*class as a random effect after handling missing data by multiple imputation. \* Adjusted P-values for trend < 0.05 across the relatives' engagement





**Figure 2.** Adolescent's diet components measured by the HELENA-Diat, according to their relatives' and peers' diet encouragement. Values are mean (SEM) of each component, calculated using linear mixed models including age, sex, and parental educational level as fixed effects and city, city\*school and city\*school\*class as a random effect after handling missing data by multiple imputation. \* Adjusted P-values for trend < 0.05 across the relatives' encouragement