Healthy eating determinants and dietary patterns in European adolescents: the HELENA study

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ABSTRACT

Background/Objectives: To assess dietary patterns (DPs) in European adolescents and to examine their relationship with healthy eating determinants.

Subject/Methods: A total of 2205 European adolescents, aged 12.5–17.5 years, were measured. A self-reported questionnaire was completed and dietary intake was measured by 24 h-dietary recalls. Principal component analysis
was performed to obtain DPs. Analyses of covariance was used to examine the associations.

**Results**: Four DPs for boys and six DPs for girls were obtained. Boys with healthier DPs, i.e. “plant-based” and “breakfast”, had lower availability of soft drinks at home, higher perception of benefits of healthy eating and higher awareness of what is a healthy diet. Girls with healthy DPs (”Mediterranean”, “plant-based”, “healthy breakfast”) had significantly higher fruits and lower soft drinks availability, higher perception of benefits, lower perception of barriers for a healthy eating and higher awareness of what is a healthy diet.

**Conclusion**: Healthier DPs were related with availability of healthy foods, perceived benefits and awareness of the diet. In contrast, those with other patterns had lower availability of fruits and higher availability of soft drinks at home, no perception of the benefits of healthy eating and they were aware that their diet was not healthy.

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**Introduction**

Childhood overweight continues to be a major and growing public health problem although recently a plateau in the prevalence of obesity has been observed in several regions of the world (Rokholm et al. 2010; Collaboration NCDRF 2017). Childhood obesity is associated with multiple comorbidities at a later age, including increased risk of type 2 diabetes, hypertension, cardiovascular diseases, fatty liver disease, sleep apnoea and cancer (Batch and Baur 2005; Daniels 2009; Rokholm et al. 2010). Adolescents with obesity are more likely to track their obesity to adulthood (The et al. 2010), as compared to non-obese, and are at higher risk for future metabolic and cardiovascular diseases (Beaglehole and Horton 2010).

There is scientific evidence that obesity follows a multifactorial model with three main components: biological, lifestyle and environmental risk factors (Boone-Heinonen et al. 2008). In adolescents, overweight is generally caused by a lack of physical activity and unhealthy eating patterns (Moreno and Rodriguez 2007; Rey-Lopez et al. 2008; Brug et al. 2010; de Gouw et al. 2010; Landsberg et al. 2010). Knowledge about actual dietary intake and its determinants is essential. The analysis of dietary patterns (DPs) gives a more holistic impression of the food consumption habits within a population (Hu 2002). Resulting DPs can be used to evaluate associations with healthy eating determinants (Michels and Schulze 2005; McNaughton et al. 2008). Therefore, understanding how determinants of the different lifestyle factors are related with food consumption and DPs is relevant to promote effective lifestyle interventions (Brug et al. 2012).
Adolescence is a period to shape and consolidate healthy eating and lifestyle behaviours (Sawyer et al. 2012). Different models and theories have been suggested to explain associations between influencing factors and food habits (Story et al. 2002). However, little is known about the psychosocial constructs influencing food habits in adolescents. Personal (attitudes, self-efficacy, perceived barriers and benefits of a healthy diet), social (perceived parents and peers behaviour and support) and environmental determinants (food availability at home/school) have been related with a healthy diet (Story et al. 2002; Vereecken et al. 2009). Also the socioeconomic status (SES) needs to be taken into account as it seems to have an impact on the diet quality of the European adolescents (Michels et al. 2018).

In another study based on the HELENA study results shown that the participants ate half of the recommended amount of fruit and vegetables and less than two-thirds of the recommended amount of milk and milk products but consumed more meat and meat products, fats and sweets than recommended. For beverage consumption, sugar-sweetened beverages, sweetened milk, low-fat milk and fruit juice provided the highest amount of energy as was shown in a previous study (Moreno et al. 2014).

The aim of the present study is to assess the association between healthy eating determinants and DPs among European adolescents.

**Material and methods**

**Study design**

HELENA-Cross-Sectional Study (CSS) was conducted in 10 European cities (Athens and Heraklion in Greece, Dortmund in Germany, Ghent in Belgium, Lille in France, Pecs in Hungary, Rome in Italy, Stockholm in Sweden, Vienna in Austria and Zaragoza in Spain) from 2006 to 2007. The main objective of the HELENA-CSS study was to obtain reliable and comparable data of a large sample of European adolescents on a variety of nutrition and health-related parameters on a standardized procedure. Details on sampling procedures and study design of the HELENA study have been reported elsewhere (Moreno et al. 2008). The study was approved by the Ethical Committee of each city involved (Béghin et al. 2008). Written informed consent was obtained from the adolescents’ parents as well as from the adolescents themselves.

In total, 3528 (46.9% boys) adolescents met the HELENA inclusion criteria: being within the age range of 12.5–17.5 years old, not participating simultaneously in a clinical trial and being free of any acute infection longer than 1 week before the inclusion (Béghin et al. 2012). Extra inclusion criteria for the purpose of the current analysis included: having provided two 24-h dietary recalls (DR) \( n = 1198 \) were excluded, 592 girls and 606
boys) and having completed the healthy diet determinants questionnaire ($n = 125$ adolescents were excluded, $66$ girls and $59$ boys). Finally, $2205$ adolescents were selected for the present analysis ($1187$ girl and $1018$ boys).

**Healthy eating determinants questionnaire**

The healthy eating determinants questionnaire (HE-Q) investigates individual and environmental key factors influencing adolescents eating behaviour, to examine potential psycho-social determinants of healthy eating (Story et al. 2002; Vereecken et al. 2009) based largely on the literature (Baranowski et al. 1999). A definition of the concept “healthy diet” was given as an introduction to the questionnaire.

Out of the $12$ sections of questions included in the HE-Q, some of them were selected in order to assess healthy eating determinants. Different aspects were covered by the nine selected questions grouped in four aspects: availability, perceived benefits, barriers and awareness.

The availability of different foods was assessed. Participants were asked about how frequently “they bring fruit to school” being the possible answers: daily, a few times/week, once a week, less than once a week, never. Also, adolescents were asked about availability of fruit and soft drinks at home measured and expressed as: completely disagree, disagree, agree/disagree, agree and strongly agree.

Three questions regarding the perceived benefits of healthy eating were assessed by asking the adolescents to rate their agreement (5-point scale: from “completely disagree” to “strongly agree”) on the following questions: a reason for me to eat healthy is: “that I lose weight”, “that I stay in good health” and “that I feel better eating healthy”.

Also barriers for healthy eating were measured by asking the participants on practical aspects: “it takes a lot of time to prepare” and aspects regarding self-discipline “that I feel the urge to eat unhealthy foods” rating their agreement on a 5-point scale: “completely disagree” to “strongly agree”.

Finally, to assess awareness (one item), adolescents completed the question “your diet is” (5-point scale: “very unhealthy” to “very healthy”).

As all the previous questions had 5-point scale responses, we re-categorized them into three: disagree, sometimes agree/disagree and agree in order to clarify the results and to make them easier to interpret. This was not performed with the awareness question as it was the only question on this determinant and we considered the nuances of the specific responses very important.

**Dietary assessment tool (HELENA DIAT)**

Dietary intakes were assessed using the self-administered, computerized 24-h DR HELENA-DIAT based on the Young Adolescents’ Nutrition Assessment
software (YANA-C) and validated in European adolescents for all nutrients and energy intake (Vereecken et al. 2008). The adolescents completed the questionnaire during school time with the assistance of researchers. Every participant was asked to fill in the HELENA-DIAT on arbitrary days, twice in a time span of 2 weeks. The usual dietary intake of nutrients and foods, also including episodically consumed foods, was estimated by the Multiple Source Method (Harttig et al. 2011).

The 43 food groups included in the HELENA-DIAT list were aggregated into 31 food groups according to their nutritional values as has been previously done for another analysis of HELENA data (Santaliestra-Pasias et al. 2014).

**Anthropometric measurements**

Weight and height were measured according to a standardized protocol. Body weight (kg) and height (cm) were measured with an electronic scale (Type SECA861, precision = 100 g, range = 0–150 kg) and stadiometer (Type sec 225, precision = 0.1 cm, range = 70–200 cm), respectively. Body mass index (BMI) (kg/m$^2$) was calculated as body weight (kg) divided by the height squared (m$^2$) and was categorized according to Cole et al. (2000, 2007).

A physical examination was performed by a physician classifying the adolescents in one of the five stages (Batch and Baur 2005; Daniels 2009; Rokholm et al. 2010; The et al. 2010; Collaboration NCDRF 2017) of pubertal maturity defined by Tanner and Whitehouse (1976).

**Socioeconomic status**

A modified version of the Family Affluence Scale (FAS) developed by Currie et al. (2008) was used as a proxy of SES. Each adolescent completed a questionnaire asking about the number of cars and computers at home, Internet availability at home and personal space at home. FAS indicates the SES of the adolescent on a scale from 0 (very low SES) to 8 (very high SES); thereafter, categories were merged into three groups: 0–2 adding up to low SES; 3–5 adding up to medium SES; and 6–8 adding up to high SES.

**Statistical analysis**

All analyses were sex-specific because of observed significant differences in food and beverage consumption patterns between boys and girls. Analysis of variance was used to compare sex-specific sample characteristics and mean DPs scores.

Principal Component Analysis (PCA) with varimax rotation was used to obtain DPs in our sample. It is a technique often used in data reduction to identify a small number of factors that explain most of the variance observed in
a much larger number of variables by defining sets highly interrelated. Each obtained DP is a linear combination of all food groups, which are weighted by their factor loading (those with an absolute value >0.3 were considered important contributors to each DP). The following criteria were used when deciding the number of components to be retained: eigenvalue >1, the screen plot (a graphical presentation of eigenvalues) and the interpretability of each component (Deshmukh-Taskar et al. 2009). The first patterns explain as much interindividual variation of the food groups as possible, the next patterns explain as much of the remaining variation as possible and so on. Each subject receives a score for each DP, with a higher score indicating a higher adherence to the respective pattern. The factor scores for every adolescent were used in subsequent analyses.

To assess the association between healthy eating determinants and DPs, we performed the analysis of covariance (ANCOVA). The analyses were stratified for sex and controlled for age, SES, energy intake and BMI. Although tanner was also measured, age was used as covariable in order to maintain a high sample size on the analysis. Furthermore, a Bonferroni post hoc test was conducted to assess pairwise comparisons. The Predictive Analytics Software (PASW) version 18.0 (SPSS Inc., Chicago, IL, USA) was used to analyse the data. P values <0.05 were considered to be statistically significant.

Results

Table 1 presents sex-specific characteristics on age, SES, pubertal stage, BMI categories and healthy eating determinants.

Four DPs in boys and six DPs in girls were derived from PCA accounting for 27.5% of the variance in food intake in boys and 40.8% in girls. The food

| Table 1. Descriptive characteristics of the sample. |
|-----------------------------------------------|
| Boys \( (n = 1018) \) | Girls \( (n = 1187) \) |
| Age (years) | Mean (SD) | 14.80 | 1.26 | 14.74 | 1.21 |
| Age categories |  |  |  |  |
| 12.5–13.99% | n (%) | 305 | 30.0 | 386 | 32.5 |
| 14–14.99% | n (%) | 261 | 25.6 | 291 | 24.5 |
| 15–15.99% | n (%) | 237 | 23.3 | 276 | 23.3 |
| 16–17.49% | n (%) | 215 | 21.1 | 234 | 19.7 |
| SES | Low (0–2) (%) | 87 | 8.5 | 133 | 11.2 |
| Medium (3–5) (%) | 575 | 56.5 | 645 | 54.3 |
| High (6–8) (%) | 356 | 33.0 | 409 | 34.5 |
| Pubertal maturity (tanner stage) |  |  |  |  |
| Stage 1–3 (%) | 344 | 33.8 | 133 | 11.2 |
| Stage 4 (%) | 424 | 41.6 | 644 | 54.3 |
| Stage 5 (%) | 250 | 24.6 | 410 | 34.5 |
| BMI \( (kg/m^2) \) | Mean (SD) | 21.28 | 3.85 | 21.20 | 3.47 |
| Normal weight (%) | 773 | 75.9 | 965 | 81.3 |
| Overweight-Obese (%) | 245 | 24.1 | 222 | 18.7 |

SD: standard deviation; SES: socioeconomic status; BMI: body mass index.
Table 2. Gender-specific factor loadings of identified dietary patterns for the HELENA subjects.

| Food groups                              | Boys            |                  |                  |                  | Girls            |                  |                  |
|------------------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|                                          | Plant-based     | Confectionary   | Animal-based    | Mediterranean   | Plant-based     | Healthy breakfast | Eggs            | Animal-based food | Carbohydrates |
|                                          |                 | and sweetened   | and processed   | Mediterranean   |                 |                  |                  |                 |              |
|                                          |                 | beverage        | food            | Mediterranean   |                 |                  |                  |                 |              |
| Water                                    | 0.418           |                 |                 | 0.554           |                 | 0.412            | 0.376            |                  |              |
| Vegetable oil                            | 0.811           |                 |                 | 0.765           |                 |                  |                  |                  |              |
| Vegetables excluding potatoes            | 0.597           |                 | 0.419           | 0.439           |                  | 0.412            | 0.376            |                  |              |
| Fruit                                    |                 |                 | 0.412           |                 |                  |                  |                  |                  |              |
| Fruit and vegetable juice                |                 | 0.349           |                 | 0.419           |                 |                  |                  |                  | 0.309         |
| Pulses                                   | 0.327           | 0.327           |                 |                 | 0.309           |                  |                  |                  |              |
| Nuts, seeds, olives and avocado          |                 |                 |                 | 0.309           |                  |                  |                  |                  |              |
| Meat substitutes and vegetarian products |                 |                 | 0.327           |                 |                  |                  |                  |                  |              |
| Soups, bouillon                          |                 |                 |                 |                 |                  |                  |                  |                  | 0.337         |
| Potatoes and starch roots                |                 |                 |                 |                 |                  |                  |                  |                  | 0.454         |
| Pasta and rice and other cereals         | 0.464           | 0.333           | 0.030           |                 | 0.464           | 0.333           | 0.030           |                 | 0.319         |
| Cheese                                   | 0.501           |                 | 0.376           |                 | 0.501           |                 | 0.376           |                 |              |
| White milk                               | 0.331           | 0.715           |                 |                 | 0.518           | 0.376           | 0.319           |              |
| Milk products                            |                 |                 |                 | 0.376           | 0.319           |                 |                  |                  |              |
| Dessert milk-based product               |                 |                 |                 |                  | 0.376           | 0.319           |                  |                  |              |
| Bread and rolls                          |                 |                 |                 |                  | 0.376           | 0.319           |                  |                  |              |
| Breakfast cereals                        | 0.610           |                 | 0.580           | 0.590           |                  |                  |                  |                  |              |
| Meat                                     | 0.323           |                 | 0.590           | 0.391           |                  |                  |                  |                  |              |
| Fish                                     |                 | 0.323           | 0.376           | 0.391           |                  |                  |                  |                  |              |
| Eggs                                     |                 |                 | 0.376           | 0.391           |                  |                  |                  |                  |              |
| Sauces                                   | 0.444           |                 | 0.580           | 0.590           |                  |                  |                  |                  |              |
| Cakes, pies and biscuit                  | 0.316           | 0.417           | 0.417           | 0.483           |                  |                  |                  |                  |              |
| Savoury snacks                           |                 |                 |                 |                 |                  |                  |                  |                  | 0.483         |
| Confectionary non-chocolate               | 0.414           |                 |                 |                 |                  |                  | 0.414           |                 |              |
| Chocolate                                | 0.382           |                 | 0.310           |                 |                  | 0.310           | 0.483           |                 |              |
| Sugar, honey, jam and syrup              |                 |                 |                 |                 |                  | 0.372           | 0.417           |                 | 0.483         |
| Butter and animal fats                   | 0.362           | 0.474           |                 |                 | 0.372           | 0.417           |                 | 0.483         |
|                                        |                 |                 |                 |                 |                  |                  | 0.372           | 0.417           | 0.483         |

(Continued)
groups loading for each DP is presented in Table 2. The observed DPs were labelled based on the foods with the highest loading (>0.30 and closer to 1).

In boys, the first component was labelled as “plant-based” DP, showing positive loading values for water, vegetable oil, vegetables excluding potatoes, pulses, pasta and rice, cheese, cakes pies and biscuits. The second component was labelled as “confectionary and sweetened beverage” DP, showing positive loading values for nuts, seeds, olives and avocado, cheese, sauces, confectionary non-chocolate, chocolate, butter and animal fats, coffee, tea, sweetened beverages, beer, wine and other alcoholic while presented an inverse loading for white milk. The third component was labelled as “breakfast” DP, showing positive loading values for white milk, breakfast cereals, butter and animal fats. The fourth component was labelled as “animal-based food and processed food” DP, showing positive loading values for meat, cakes, pies and biscuit, chocolate, sweetened beverages and an inverse loading for sugar, honey, jam and syrup, butter and animal fats, coffee and tea.

In girls, the first component was labelled as “Mediterranean” DP, showing positive loading values for water, vegetable oil, vegetable excluding potatoes, pulses, pasta and rice and others cereals and an inverse loading for sweetened beverages, potatoes and starch roots. The second component was labelled as “plant-based” DP, showing positive loading values for vegetables, fruit, cheese, bread and rolls, sugar, honey, jam and syrup, coffee and tea. The third component was labelled as “healthy breakfast” DP, showing positive loading values for fruit, cheese, milk products, breakfast cereals and an inverse loading for savoury snacks and sweetened beverages. The fourth component was labelled as “eggs” DP, showing positive loading values for soup bouillon and eggs and an inverse loading for pasta, rice and other cereals and cakes, pies and biscuit. The fifth component was labelled as “animal-based food” DP, showing positive loading values for white milk, starch roots, meat and inversely with sugar, honey, jam and syrup and coffee and tea. The last component was labelled as “carbohydrates” DP, showing positive loading values for pasta, rice and other cereals, cakes, pies and biscuit, sauces, sugar, honey, jam and syrup.

Tables 3 and 4 show the results of the ANCOVA analysis assessing the association between the healthy eating determinants and the DPs for boys and girls, respectively.

Regarding availability, those boys with the “animal-based and processed food” DP stated more to bring fruit to school in a daily basis in comparison with those that stated less than once a week/never ($p = 0.003$). Also, those boys with a “breakfast” DP reported to agree on “There is always fruit available at home that I like” in comparison with those that disagree ($p = 0.001$). In contrast, boys with a “confectionary and sweetened beverage” pattern showed disagreement in that question ($p = 0.001$). Boys with a “confectionary and sweetened beverage” pattern reporting to agree on
| Food groups                               | Boys                  |              | Girls                  |              |
|-------------------------------------------|-----------------------|--------------|------------------------|--------------|
|                                           | Plant-based           | Confectionary and sweetened beverage | Breakfast   | Animal-based and processed food | Mediterranean | Plant-based | Healthy breakfast | Eggs | Animal-based food | Carbohydrates |
| Margarine and lipids of mixed origins     | 0.368                 | −0.426       | 0.356                  | −0.510       |
| Coffee and tea                           | 0.574                 | 0.353        | −0.487                 | −0.360       |
| Sweetened beverages                      | 0.307                 |              |                        |              |
| Beer, wine and other alcoholic beverages  |                       |              |                        |              |
| Percentage of variance explained          | 8.444                 | 6.661        | 6.323                  | 6.054        |
| by individual pattern                    | 8.219                 | 7.245        | 6.812                  | 6.345        |
| Total cumulative variance explained       | 27.433                | 40.80        |

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Table 3. ANCOVA analysis for association between healthy eating determinants and dietary patterns in boys.

| Availability                                      | Plant-based | Confectionary and sweetened beverage | Breakfast | Animal-based and processed food | p-Value |
|---------------------------------------------------|-------------|--------------------------------------|-----------|---------------------------------|---------|
| I bring fruit to school                           |             |                                      |           |                                 |         |
| Daily/often                                       | −0.141 (−0.271, −0.011) | 0.027 (−0.089, 0.143) | −0.011 (−0.156, 0.134) | 0.190 (0.042, 0.338) |         |
| Once a week                                       |−0.044 (−0.244, 1.56) | 0.007 (−0.171, 0.186) | 0.142 (−0.081, 0.366) | 0.182 (−0.046, 0.409) |         |
| Less than once a week/never                       | 0.036 (−0.026, 0.097)* | −0.008 (−0.063, 0.047) | 0.867 | −0.011 (−0.080, 0.057) | 0.428 |
| There is always fruit available at home that I like|             |                                      |           |                                 |         |
| Disagree                                          | −0.109 (−0.332, 0.115) | 0.288 (0.091, 0.485) | −0.432 (−0.679, −0.185) | 0.013 (−0.241, 0.268) |         |
| Sometimes agree/disagree                          | −0.112 (−0.258, 0.034) | 0.134 (0.005, 0.262) | −0.085 (−0.246, 0.076) | −0.176 (−0.343, −0.10) |         |
| Agree                                             | 0.026 (−0.033, 0.086) | 0.140 | −0.044 (−0.097, 0.009)*,** | 0.001 | 0.045 (−0.021, 0.111)* | 0.001 |
| There is always soft drink available at home that I like|             |                                      |           |                                 |         |
| Disagree                                          | 0.018 (−0.088, 0.123) | −0.130 (−0.233, −0.038) | 0.305 (0.189, 0.420) | 0.034 (−0.087, 0.156) |         |
| Sometimes agree/disagree                          | 0.165 (0.061, 0.269) | −0.159 (−0.251, −0.068) | 0.070 (−0.444, 0.184)* | −0.034 (−0.153, 0.086) |         |
| Agree                                             | −0.101 (−0.179, −0.24)** | <0.001 | 0.158 (0.089, 0.226)*,** | <0.001 | −0.205 (−0.290, −0.120)*,** | <0.001 |
| Benefits perceived                                |             |                                      |           |                                 |         |
| A reason or benefit for me to eat healthy is: that I lose weight |             |                                      |           |                                 |         |
| Disagree                                          | −0.078 (−0.166, 0.010) | 0.064 (−0.140, 0.142) | 0.069 (−0.028, 0.167) | 0.089 (−0.012, 0.189) |         |
| Sometimes agree/disagree                          | 0.013 (−0.106, 0.132) | −0.053 (−0.156, 0.054) | 0.081 (−0.051, 0.214) | −0.018 (−0.154, 0.118) |         |
| Agree                                             | 0.086 (−0.011, 0.184) | 0.071 | −0.049 (−0.136, 0.037) | 0.122 | −0.131 (−0.239, −0.023)*,** | 0.015 |
| A reason or benefit for me to eat healthy is: that I stay in good health |             |                                      |           |                                 |         |
| Disagree                                          | −0.392 (−0.644, −0.139) | 0.295 (0.070, 0.521) | −0.252 (−0.536, 0.032) | −0.015 (−0.306, 0.277) |         |
| Sometimes agree/disagree                          | −0.277 (−0.463, −0.118) | 0.202 (0.060, 0.343) | −0.067 (−0.246, 0.112) | −0.035 (−0.219, 0.148) |         |
| Agree                                             | 0.057 (−0.001, 0.115)** | <0.001 | −0.043 (−0.095, 0.008)*,** | <0.001 | 0.022 (−0.043, 0.087) | 0.136 |
| A reason or benefit for me to eat healthy is: that I feel better eating healthy |             |                                      |           |                                 |         |

(Continued)
### Table 3. (Continued).

|                      | Plant-based                        | Confectionary and sweetened beverage | Breakfast | Animal-based and processed food |
|----------------------|------------------------------------|--------------------------------------|-----------|-------------------------------|
|                      | Mean (CI 95%) p-Value               | Mean (CI 95%) p-Value                 | Mean (CI 95%) p-Value | Mean (CI 95%) p-Value |
| Disagree             | $-0.214 (-0.354, 0.074)$            | $0.199 (0.075, 0.323)$                | $-0.212 (-0.367, -0.056)$ | $-0.195 (-0.354, -0.035)$ |
| Sometimes agree/disagree | $0.034 (-0.078, 0.146)$          | $0.045 (-0.055, 0.144)$              | $-0.014 (-0.138, 0.111)$ | $-0.012 (-0.140, 0.116)$ |
| Agree                | $0.038 (-0.030, 0.106)^*$           | $-0.065 (-0.126, -0.005)^*$          | $0.001$    | $0.010$                       |
|                      |                                    | $0.055 (-0.021, 0.131)^*$            | $0.010$    | $0.048 (-0.030, 0.125)^*$     | $0.028$           |
| **Barriers**         |                                    |                                      |            |                               |                   |
| A barrier or a reason why I do not (always) eat healthy is: that it takes a lot of time to prepare | $0.010 (-0.058, 0.077)$          | $-0.006 (-0.066, 0.054)$              | $-0.013 (-0.088, 0.062)$ | $0.012 (-0.065, 0.089)$  |
| Disagree             |                                    |                                      |            |                               |                   |
| Sometimes agree/disagree | $-0.058 (-0.174, 0.058)$         | $0.064 (-0.039, 0.168)$              | $0.023 (-0.107, 0.152)$ | $-0.008 (-0.141, 0.124)$  |
| Agree                | $0.041 (-0.100, 0.183)$           | $0.503$                             | $0.239$    | $0.860$                       |
|                      |                                    | $0.073 (-0.199, 0.052)$              | $0.222 (-0.136, 0.179)$ | $-0.056 (-0.218, 0.106)$  |
|                      |                                    |                                      |            |                               | $0.753$           |
| A barrier or a reason why I do not (always) eat healthy is: that I feel the urge to eat unhealthy foods | $0.034 (-0.035, 0.103)$          | $-0.039 (-0.101, 0.022)$              | $-0.008 (-0.085, 0.068)$ | $0.024 (-0.055, 0.103)$  |
| Disagree             |                                    |                                      |            |                               |                   |
| Sometimes agree/disagree | $0.002 (-0.110, 0.113)$         | $0.069 (-0.030, 0.168)$              | $-0.085 (-0.208, 0.039)$ | $-0.090 (-0.218, 0.037)$  |
| Agree                | $-0.133 (-0.267, 0.002)$         | $0.099$                             | $0.142$    | $0.051$                       |
|                      |                                    | $0.043 (-0.077, 0.162)$              | $0.155 (0.005, 0.305)$ | $0.030 (-0.124, 0.184)$  |
| **Awareness**        |                                    |                                      |            |                               | $0.297$           |
| Your diet is         |                                    |                                      |            |                               |                   |
| Very unhealthy       | $-0.288 (-0.483, -0.093)$          | $0.247 (0.074, 0.420)$                | $-0.548 (-0.762, -0.334)$ | $-0.176 (-0.401, 0.048)$  |
| Rather unhealthy     | $-0.100 (-0.208, 0.007)$          | $0.102 (0.007, 0.198)$                | $-0.137 (-0.256, -0.019)^*$ | $-0.052 (-0.176, 0.072)$  |
| Not unhealthy/not healthy | $0.042 (-0.055, 0.140)^*$         | $-0.029 (-0.116, 0.057)$              | $0.051 (-0.056, 0.158)^*$ | $-0.001 (-0.113, 0.111)$  |
| Rather healthy       | $0.053 (-0.042, 0.148)^*$          | $-0.062 (-0.146, 0.022)^*$           | $0.109 (0.004, 0.213)^*$  | $0.048 (-0.061, 0.157)$  |
| Very healthy         | $0.301 (0.074, 0.528)^*$,***       | $0.001$                             | $-0.292 (-0.494, -0.091)^*$ | $<0.001$  |
|                      |                                    | $0.455 (0.205, 0.704)^*$,***         | $<0.001$  | $0.162 (-0.099, 0.423)$  |

Subject factor loading for each DPs and 95% confidence interval (CI), by Healthy Eating determinants questioner, controlling by body mass index, z score, SES, age and energy intake. Factor loading and 95% CI in bold means higher factor loading within the responses. Bonferroni adjustment for multiple comparisons; associations between responses are expressed as *p < 0.05 using response 1 as reference, **p < 0.05 using response 2 as reference and ***p < 0.05 using response 3 as reference. Significances in bold when p < 0.005.
|                | Mediterranean Mean (CI 95%) | p-Value | Plant-based Mean (CI 95%) | p-Value | Healthy breakfast Mean (CI 95%) | p-Value | Eggs Mean (CI 95%) | p-Value | Animal-based food Mean (CI 95%) | p-Value | Carbohydrates Mean (CI 95%) | p-Value |
|----------------|-----------------------------|---------|---------------------------|---------|--------------------------------|---------|-------------------|---------|---------------------------------|---------|-------------------------------|---------|
| **Availability** |                             |         |                           |         |                                |         |                   |         |                                 |         |                               |         |
| I bring fruit to school | Daily/often: -0.248 (-0.360, -0.137) | 0.173   | 0.370 (0.261, 0.479) | 0.003   | -0.111 (-0.224, 0.003) | 0.209 (0.102, 0.316) | -0.218 (-0.316, 0.120) |         |                                |         |                               |         |
|                  | Once a week: -0.047 (-0.255, 0.161) | 0.040*  | 0.196*                    | 0.230   | 0.019 (-0.193, 0.082) | 0.282   | 0.010 (-0.172, 0.192) |         |                                |         |                               |         |
|                  | Less that once a week/never: 0.099 (0.031, -0.167)* | <0.001  | -0.050 (-0.111, -0.072)* | 0.111   | 0.042 (-0.027, 0.079) | -0.089 (-0.154, -0.024)* | 0.081 (0.022, 0.140)* |         |                                |         |                               |         |
| **There is always fruit available at home that I like** | Disagree: -0.147 (-0.402, 0.108) | -0.312 (-0.536, 0.177) | -0.075 (-0.326, 0.407) | -0.150 (-0.107, 0.059) | -0.126 (-0.097, 0.303) | 0.047   | -0.059 (-0.184, 0.126) | -0.097, 0.349 |                                |         |                               |         |
|                  | Sometimes agree/ disagree: -0.002 (-0.142, 0.138) | -0.085 (-0.208, 0.038) | -0.240 (-0.378, 0.084) | -0.057 (-0.198, 0.016) | 0.53 (-0.070, 0.175) | 0.125   | -0.118 (-0.252, 0.53) | -0.070, 0.349 |                                |         |                               |         |
|                  | Agree: 0.011 (-0.052, 0.075) | 0.497   | 0.035 (-0.020, 0.005) | 0.005 (-0.10, 0.115)** | 0.068   | 0.078   | 0.118 (-0.043, 0.170) | -0.073, 0.316 |                                |         |                               |         |
| **There is always soft drink available at home that I like** | Disagree: 0.057 (-0.037, 0.152) | 0.041 (-0.043, 0.420) | 0.329 (0.238, 0.420) | 0.180 (0.085, 0.275) | 0.000 (-0.092, 0.126) | 0.09   | -0.001 (-0.125, 0.090) | -0.209, 0.043 |                                |         |                               |         |
|                  | Sometimes agree/ disagree: 0.128 (0.020, 0.236) | -0.004 (-0.100, 0.092) | -0.061 (-0.165, 0.042) | -0.029 (0.137, 0.079) | 0.006 (-0.088, 0.100) | 0.409   | -0.029 (-0.125, 0.044) | -0.059, 0.148 |                                |         |                               |         |
|                  | Agree: -0.142 (-0.234, -0.050)** | -0.039 (-0.120, 0.419) | -0.270 (-0.358, -0.181)** | -0.144 (-0.236, -0.052)* | -0.017 (-0.125, 0.117) | 0.197   | 0.117 (0.036, 0.305) | <0.001 |                                |         |                               |         |
| **Benefits perceived** | A reason or benefit for me to eat healthy is: I lose weight | Disagree: -0.083 (-0.205, 0.040) | -0.060 (-0.169, 0.276) | 0.155 (0.033, 0.207) | 0.084 (-0.040, 0.207) | 0.097 (-0.021, 0.024) | 0.069 (-0.038, 0.177) |         |                                 |         |                               |         |
|                  | Sometimes agree/ disagree: -0.083 (-0.212, 0.045) | 0.024 (-0.090, 0.168) | 0.040 (-0.087, 0.048) | -0.081 (-0.211, 0.048) | 0.005 (-0.118, 0.128) | 0.082   | -0.030 (-0.143, 0.108) | -0.038, 0.177 |                                |         |                               |         |

(Continued)
### Table 4. (Continued).

| Mediterranean | Plant-based | Healthy breakfast | Eggs | Animal-based food | Carbohydrates |
|---------------|-------------|-------------------|------|-------------------|---------------|
| **Mean (CI 95%)** | **Mean (CI 95%)** | **Mean (CI 95%)** | **Mean (CI 95%)** | **Mean (CI 95%)** | **Mean (CI 95%)** |
| **p-Value** | **p-Value** | **p-Value** | **p-Value** | **p-Value** | **p-Value** |
| Agree | 0.067 (~0.011, 0.145) | 0.016 (~0.053, 0.085) | 0.478 | 0.007 | 0.005 (~0.084, 0.073) | 0.048 (~0.122, 0.027) | 0.018 (~0.081, 0.361) |
| Disagree | ~0.189 (~0.561, 0.184) | ~0.103 (~0.433, 0.227) | ~0.451 (~0.819, 0.083) | ~0.012 (~0.388, 0.0364) | ~0.023 (~0.350, 0.501) | ~0.023 (~0.350, 0.030) |
| Sometimes agree/disagree | ~0.233 (~0.447, 0.20) | ~0.154 (~0.343, 0.035) | ~0.302 (~0.513, 0.091) | ~0.079 (~0.295, 0.137) | 0.019 (~0.185, 0.224) | 0.010 (~0.177, 0.198) |
| Agree | 0.024 (~0.035, 0.083) | 0.013 (~0.039, 0.065) | 0.205 | 0.033 (~0.025, 0.091)** | 0.008 (~0.051, 0.68) | ~0.008 (~0.064, 0.049) | 0.001 (~0.051, 0.985) |
| Disagree | ~0.305 (~0.507, 0.102) | ~0.105 (~0.285, 0.075) | ~0.245 (~0.455, 0.046) | 0.006 (~0.199, 0.211) | 0.003 (~0.192, 0.197) | 0.037 (~0.141, 0.215) |
| Sometimes agree/disagree | ~0.042 (~0.082, 0.166)** | ~0.034 (~0.144, 0.076) | ~0.238 (~0.360, 0.115) | 0.010 (~0.116, 0.135) | 0.080 (~0.039, 0.199) | 0.031 (~0.079, 0.140) |
| Agree | 0.023 (0.043, 0.089)** | 0.009 | 0.019 (~0.039, 0.078) | 0.092 (~0.027, 0.157)** | <0.001 | ~0.001 (~0.068, 0.037) | 0.098 (~0.067, 0.736) |
| Disagree | ~0.096 (~0.096, 0.131) | 0.067 (~0.004, 0.067) | ~0.005 (~0.076, 0.067) | 0.015 (~0.058, 0.088) | 0.003 (~0.066, 0.072) | ~0.035 (~0.098, 0.028) |
| Sometimes agree/disagree | ~0.010 (~0.102, 0.122) | ~0.018 (~0.116, 0.080) | ~0.085 (~0.026, 0.196) | ~0.030 (~0.143, 0.082) | ~0.018 (~0.125, 0.089) | 0.076 (~0.022, 0.174) |
| Agree | ~0.116 (~0.268, 0.037) | 0.263 | ~0.274 (~0.407, 0.140)** | <0.001 | ~0.145 (~0.296, 0.053) | 0.004 (~0.149, 0.158) | 0.004 (~0.142, 0.150) | 0.019 (~0.114, 0.153) |
| Disagree | ~0.029 (~0.017, 0.050) | 0.028 (~0.042, 0.098) | 0.043 (~0.036, 0.121) | ~0.044 (~0.124, 0.035) | ~0.023 (~0.052, 0.099) | ~0.109 (~0.177, 0.040) |
| Sometimes agree/disagree | ~0.096 (~0.021, 0.192) | ~0.038 (~0.133, 0.056) | ~0.025 (~0.131, 0.081) | 0.041 (~0.066, 0.149) | 0.022 (~0.080, 0.124) | 0.126 (~0.033, 0.219)** |

**A barrier or reason why I do not (always) eat healthy is:**

- that I stay in good health
- that I feel the urge to eat unhealthy foods
- that I feel better eating healthy
- that it takes a lot of time to prepare
- that I feel the urge to eat unhealthy foods

*Denotes significance at *p* < 0.05
**Denotes significance at *p* < 0.01
***Denotes significance at *p* < 0.001

(Continued)
Table 4. (Continued).

|                          | Mediterranean Mean (CI 95%) |   | Plant-based Mean (CI 95%) |   | Healthy breakfast Mean (CI 95%) |   | Eggs Mean (CI 95%) | p-Value |   | Animal-based food Mean (CI 95%) | p-Value |   | Carbohydrates Mean (CI 95%) | p-Value |
|-------------------------|-----------------------------|---|---------------------------|---|-------------------------------|---|-------------------|---------|---|-----------------------------|---------|---|-----------------------------|---------|
| Agree                   | −0.036 (−0.158, 0.085)      | 0.191 | −0.022 (−0.130, 0.085)    | 0.491 | −0.074 (−0.194, 0.047)       | 0.250 | 0.060 (−0.062, 0.183)     | 0.264 |   | −0.094 (−0.211, 0.022)     | 0.216 |   | 0.098 (−0.007, 0.204)*     | <0.001 |
| Awareness               |                             |     |                          |     |                               |     |                   |         |     |                             |         |     |                             |         |
| Very unhealthy          | −0.249 (−0.479, −0.021)     |      | −0.183 (−0.382, 0.16)    |      | −0.355 (−0.574, −0.136)      |      | 0.356 (0.127, 0.585)     |      | −0.024 (−0.242, 0.194)     |      | 0.090 (−0.108, 0.289)      |      |
| Rather unhealthy        | 0.017 (−0.089, 0.122)       |      | −0.135 (−0.227, −0.042)  |      | −0.280 (−0.381, −0.178)      |      | 0.007 (−0.099, 0.113)    |      | −0.063 (−0.164, 0.038)     |      | 0.044 (−0.048, 0.136)      |      |
| Not unhealthy/not healthy | −0.011 (−0.114, 0.091)      |      | −0.062 (−0.151, 0.028)   |      | −0.034 (−0.133, 0.065)       |      | −0.051 (−0.154, 0.052)   |      | −0.056 (−0.154, 0.042)     |      | 0.087 (−0.002, 0.177)      |      |
| Rather healthy          | 0.015 (−0.087, 0.118)       |      | 0.152 (0.063, 0.241)     |      | 0.288 (0.190, 0.386)         |      | 0.007 (−0.096, 0.110)    |      | 0.095 (−0.003, 0.193)      |      | −0.94 (−0.183, −0.004)     |      |
| Very healthy            | 0.227 (0.029, 0.484)        | 0.101 | 0.433 (0.209, 0.657)     |      | 0.471 (0.225, 0.718)         |      | −0.189 (−0.447, 0.069)   |      | 0.100 (−0.146, 0.345)      |      | −0.308 (−0.532, 0.002)     |      |

Subject factor loading for each DPs and 95% confidence interval (CI), by Healthy Eating determinants questioner, controlling by body mass index, z score, SES, age and energy intake. Factor loading and 95% CI in bold means higher factor loading within the responses. Bonferroni adjustment for multiple comparisons; associations between responses are expressed as *p < 0.05 using response 1 as reference, **p < 0.05 using response 2 as reference. Significances in bold when p < 0.005.
“There is always soft drink available at home that I like” \((p < 0.001)\). In contrast, those with a “breakfast” pattern showed disagreement on that response \((p < 0.001)\) while those with a “plant-based” pattern reported sometimes agree/disagree \((p < 0.001)\) on that specific question.

Regarding benefits perceived, boys with a “breakfast” DP reported to sometimes agree/disagree in the question “a reason or benefit for me to eat healthy is: that I lose weight” when compared with those that agree \((p = 0.015)\). In the question “a reason or benefit for me to eat healthy is: that I stay in good health” those boys with a “plant-based” DP showed agreement in comparison with those that disagree; while boys with a “confectionary and sweetened beverage” DP showed disagreement on that question \((p < 0.001)\). Those boys with a “plant-based”, “breakfast” and “animal-based and processed food” DP showed agreement on the question “a reason or benefit for me to eat healthy is: that I feel better eating healthy” in comparison with those that disagree \((p = 0.005, p = 0.010, p = 0.028\) respectively). In contrast, those with a “confectionary and sweetened beverage” DP showed higher disagreement than those that agree to that specific question \((p = 0.001)\). Regarding the barrier’s section, we did not find any significant association between the responses to the questions and the DPs in boys.

For the section awareness of their diet, those boys with the considered healthy DPs (plant-based and breakfast) reported to agree on the statement about the healthiness of their diet \((p \leq 0.001)\). In contrast, children with a “confectionary and sweetened beverage” DP showed disagreement in the healthiness of their diet in comparison with those who agree \((p < 0.001)\).

Those girls with “plant-based”, “healthy breakfast” and “animal-based food” DP stated to bring food daily/often to the school \((p < 0.001)\). In contrast, those with a “Mediterranean” and “carbohydrates” pattern stated to bring food to the school “less than once a week/never” in comparison with those who did it daily/often \((p < 0.001)\). Those girls with the considered healthy patterns (“healthy breakfast” and “plant-based” DPs) showed agreement regarding the availability of fruit at home in comparison with the other responses \((p = 0.001, p = 0.005)\). Those girls with the “carbohydrates” DP reported to agree on “There is always soft drink available at home that I like” \((p < 0.001)\). Girls with “healthy breakfast” and “egg-protein” DPs showed disagreement regarding availability on soft drinks at home \((p < 0.001)\). While those with the “Mediterranean” DP reported to sometimes agree/disagree on that specific question \((p < 0.001)\).

Regarding benefits perceived, those girls with a “healthy breakfast” DP showed disagreement on “a reason or benefit for me to eat healthy is that I lose weight” in comparison with those that agree \((p = 0.007)\). For the question “a reason or benefit for me to eat healthy is: that I stay in good health”, those children with a “Mediterranean” and “healthy breakfast” DPs stated agreement in comparison with the other responses \((p < 0.045)\) for the first and sometimes
agree/disagree and disagree for the second ($p < 0.001$). Girls with a “healthy breakfast” DP reported to agree on “a reason or benefit for me to eat healthy is: that I feel better eating healthy” in comparison with the other responses ($p < 0.001$). In contrast, those with “Mediterranean DP” reported to sometimes agree/disagree ($p = 0.009$).

For barriers, those girls with a “plant-based” DP showed disagreement on the question “a barrier or reason why I do not (always) eat healthy is: that it takes a lot of time to prepare” in comparison with those that agree ($p < 0.001$). In contrast, girls with a “carbohydrate” DP reported to sometimes agree/disagree on the statement “a barrier or reason why I do not (always) eat healthy is: that feel the urge to eat unhealthy foods” in comparison with those that agree ($p < 0.001$).

Regarding awareness of their diet, on the question: “your diet is” those girls with “plant-based” and “healthy breakfast” DPs showed adherence to the response very healthy in comparison to the other responses ($p < 0.001$). However, girls with an “egg protein” and a “carbohydrates” DP showed adherence to the response very unhealthy ($p = 0.016, p = 0.002$, respectively).

**Discussion**

The main findings from this study in European adolescents are that some determinants of healthy eating are associated with the identified DPs. Among European adolescents, we found different DPs in boys and girls. In boys, the DPs considered healthier were “plant-based” DP and “breakfast” DP and in girls were “plant-based” DP, “Mediterranean” DP and “healthy breakfast” DP.

The identified DPs were to some extent comparable to other patterns previously found in European adolescents from the HELENA Study (Santaliestra-Pasías et al. 2014). DPs are sample-dependant; the patterns found in another study within the HELENA study are similar but not the same. In our study, for boys, the most predominant DP was the “plant-based” pattern and, among girls, the “Mediterranean” pattern. All DPs found among European girls explained 40.80% of variance in food group intake, while among boys, only explained 27.5% of variance. This may indicate that there is more inter-individual variability within the diet of boys and/or girls have more homogeneous food preferences.

The observed associations between healthy eating determinants and DPs support results from previous studies on food consumption, such as fruits consumption (van der Horst et al. 2007). Previous studies suggest that competing availability of more-healthful and less-healthful food choices is important (Ding et al. 2012). In our study, we found that adolescents stating that they had fruit available and no soft drinks available at home were the ones having the considered healthier DP.
("breakfast" pattern in boys and "healthy breakfast" in girls) while the opposite was found for the pattern "confectionary and sweetened beverages" in boys and for the pattern "carbohydrates" in girls but only for the availability of soft drinks at home. Fruit availability is likely to be a combination of personal (habit), social (parents) and physical environmental (availability) elements (De Bourdeaudhuij et al. 2008) and should be encouraged in adolescents to support tracking of healthy eating behaviours.

Unhealthy food availability at home and father’s consumption of high-energy drinks was positively associated with girl’s consumption of high-energy drinks (Campbell et al. 2007). In the literature it was observed that availability at home of less healthy foods and beverages was also associated with a low consumption of vegetables and fruits (Larson et al. 2008) while availability of fruits and vegetables at home had a positive influence on its consumption in adolescents (De Bourdeaudhuij et al. 2008). Parents should be encouraged to reduce the availability of less healthy foods and to increase the availability of fruits and vegetables to increase their consumption.

Concerning the perceived benefits, boys agreeing on the link between diet and health were the ones with the considered healthy patterns ("plant-based" and "breakfast" in boys and "healthy breakfast" in girls). Nevertheless, those boys with “confectionary and sweetened beverages” DP did not agree on feeling better or staying in good health as reasons to eat healthy. In a qualitative study with 12 focus groups discussion of adolescents, healthy eating was generally viewed as unnatural, unpleasant short-term activity to avoid obesity or enhance attractiveness (Stevenson et al. 2007). Similar to the current study, other research has also related that one of the most important benefits of healthy eating was enhancement of physical sensation where the participants commonly used descriptive words such as “clean”, “refresh”, “feeling good” and “revived” but this study has not been compared with patterns or intakes. (O’Dea 2003) Other study, with Spanish participants (aged 15 years and older), subjects declared that the most frequently mentioned benefit was “prevent disease/stay healthy” (Holgado et al. 2000). We have observed that there were differences by DP in the benefits perceived that need to be taken into account when assessing healthy eating determinants.

In relation to the barriers, in adolescence they could be very diverse including a lack of sense of urgency about personal health, taste preferences, lack of will-power among others (Neumark-Sztainer et al. 1999; Pinho et al. 2018). In our sample, the barriers were the healthy eating determinant with less significant associations. However, low availability of fruit and vegetables could be also considered a barrier for healthy eating and we did find associations with DPs on that question.
Finally, adolescents with considered healthy patterns (“plant-based” DP and “breakfast” DP in boys along with “Mediterranean”, “healthy breakfast” and “plant-based” in girls) were aware about the healthiness of their diet. Similarly, boys with “confectionary and sweetened beverages” DP said that their diet was very unhealthy. Adolescents who believed their dietary practices to be healthy were in fact consuming a healthier diet overall, suggesting that having an awareness of nutrition guidelines does influence the dietary behaviours of some individuals (De Bourdeaudhuij et al. 2008) as it was observed in our study.

Strengths of the study include a large and culturally diverse sample of European adolescents. The highly standardized procedures used within the HELENA study are also an important strength (Moreno et al. 2008). In addition, the use of multiple 24 h-DR in estimating dietary intake and the association with determinants of healthy diet are an important asset of this study. The HELENA DIAT tool has been indicated as a good method to collect detailed dietary information from adolescents and was received well by the study participants (Vereecken et al. 2005). Using PCA to generate DPs shows which foods tend to be consumed together, and relating these patterns to other factors such as demographics, lifestyle and health helps to tailor and set priorities for health promotion and also to better understand the role of diet in relation to disease risk. In addition, the use of DPs takes into account interactions across the food matrix which is not possible using the single nutrient approach.

Our study also has limitations. PCA, as a statistical technique, requires some arbitrary decisions on the extraction and interpretation of factors. The differences that could be present between countries were not accounted. In adolescents, there are other factors that could influence on their dietary habits. For example, there is an association between influence of friendship concerning junk food in adolescents (Guidetti et al. 2012), but it was not assessed in the HE-Q. Also, role of parents has an impact in choices as has been observed in the HELENA study (Vanhelst et al. 2018) but we focused in the questions regarding adolescents although parents were indirectly included (i.e. food availability at home depends on them). As a limitation, in this study we did not included physical activity in the analysis. In addition, food consumption is based on self-reported questionnaires where errors in reporting are possible; nevertheless, questionnaire use is the most common method due to low-cost and ease of administration in a large European sample, and this questionnaire has been tested and validated indicating acceptable accuracy (Vereecken et al. 2008).

In conclusion, some personal and environmental determinants were associated with healthier DPs both in boys and girls. Adolescent’s parents should guarantee healthy foods availability at home, especially fruits and vegetables and limit the availability of unhealthy foods, such as sugar sweetened beverages.
Those adolescents with healthier DPs perceived the health benefits of a healthy diet, compared to those with other patterns who stated that a healthy diet is important just to lose weight. Finally, girls and boys that were aware of the healthiness of their diet had the healthiest DPs. Adolescents’ knowledge about the links between food and health needs to be perceived, especially for those with less healthy DPs. The relevance of the identified determinants of healthy eating behaviours should be taken into account in future prevention programs.

**Disclosure statement**

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**References**

Baranowski T, Cullen KW, Baranowski J. 1999. Psychosocial correlates of dietary intake: advancing dietary intervention. Annu Rev Nutr. 19:17–40.

Batch JA, Baur LA. 2005. Management and prevention of obesity and its complications in children and adolescents. Med J Aust. 182(3):130–135.

Beaglehole R, Horton R. 2010. Chronic diseases: global action must match global evidence. Lancet. 376(9753):1619–1621.

Béghin L, Castera M, Manios Y, Gilbert CC, Kersting M, De Henauw S, Kafatos A, Gottrand F, Molnar D, Sjöström M, et al. 2008. Quality assurance of ethical issues and regulatory aspects relating to good clinical practices in the HELENA Cross-Sectional Study. Int J Obes (Lond). 32 Suppl 5(Suppl 5):S12–8.

Béghin L, Huybrechts I, Vicente-Rodriguez G, De Henauw S, Gottrand F, Gonzales-Gross M, Dallongeville J, Sjöström M, Leclercq C, Dietrich S, et al. 2012. Main characteristics and participation rate of European adolescents included in the HELENA study. Arch Public Health. 70(1):14.

Boone-Heinonen J, Gordon-Larsen P, Adair LS. 2008. Obesogenic clusters: multidimensional adolescent obesity-related behaviors in the U.S. Ann Behav Med. 36 (3):217–230.

Brug J, Lien N, Klepp KI, van Lenthe FJ. 2010. Exploring overweight, obesity and their behavioural correlates among children and adolescents: results from the Health-promotion through Obesity Prevention across Europe project. Public Health Nutr. 13(10A):1676–1679.
Brug J, van Stralen MM, Te Velde SJ, Chinapaw MJM, De Bourdeaudhuij I, Lien N, Bere E, Maskini V, Singh AS, Maes L, et al. 2012. Differences in weight status and energy-balance related behaviors among schoolchildren across Europe: the ENERGY-project. PLoS One. 7(4):e34742.

Campbell KJ, Crawford DA, Salmon J, Carver A, Garnett SP, Baur LA. 2007. Associations between the home food environment and obesity-promoting eating behaviors in adolescence. Obesity (Silver Spring). 15(3):719–730.

Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. 2000. Establishing a standard definition for child overweight and obesity worldwide: international survey. Bmj. 320(7244):1240–1243.

Cole TJ, Flegal KM, Nicholls D, Jackson AA. 2007. Body mass index cut offs to define thinness in children and adolescents: international survey. Bmj. 335(7612):194.

Collaboration NCDRF. 2017. Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128.9 million children, adolescents, and adults. Lancet. 390(10113):2627–2642.

Currie C, Molcho M, Boyce W, Holstein B, Torsheim T, Richter M. 2008. Researching health inequalities in adolescents: the development of the Health Behaviour in School-Aged Children (HBSC) family affluence scale. Soc Sci Med. 66(6):1429–1436.

Daniels SR. 2009. Complications of obesity in children and adolescents. Int J Obes (Lond). 33(Suppl 1):S60–S65.

De Bourdeaudhuij I, Te Velde S, Brug J, Due P, Wind M, Sandvik C, Maes L, Wolf A, Perez Rodrigo C, Yngve A, et al. 2008. Personal, social and environmental predictors of daily fruit and vegetable intake in 11-year-old children in nine European countries. Eur J Clin Nutr. 62(7):834–841.

de Gouw L, Klepp KI, Vigneronova J, Lien N, Steenhuis IH, Wind M. 2010. Associations between diet and (in)activity behaviours with overweight and obesity among 10-18-year-old Czech Republic adolescents. Public Health Nutr. 13(10A):1701–1707.

Deshmukh-Taskar PR, O’Neil CE, Nicklas TA, Yang S-J, Liu Y, Gustat J, Berenson GS. 2009. Dietary patterns associated with metabolic syndrome, sociodemographic and lifestyle factors in young adults: the Bogalusa Heart Study. Public Health Nutr. 12(12):2493–2503.

Ding D, Sallis JF, Norman GJ, Saelens BE, Harris SK, Kerr J, Rosenberg D, Durant N, Glanz K. 2012. Community food environment, home food environment, and fruit and vegetable intake of children and adolescents. J Nutr Educ Behav. 44(6):634–638.

Guidetti M, Conner M, Prestwich A, Cavazza N. 2012. The transmission of attitudes towards food: twofold specificity of similarities with parents and friends. Br J Health Psychol. 17(2):346–361.

Hattig U, Haubrock J, Knuppel S, Boehing H, Consortium E. 2011. The MSM program: web-based statistics package for estimating usual dietary intake using the Multiple Source Method. Eur J Clin Nutr. 65(Suppl 1):S87–91.

Holgado B, de Irala-Estevez J, Martinez-Gonzalez MA, Gibney M, Kearney J, Martinez JA. 2000. Barriers and benefits of a healthy diet in Spain: comparison with other European member states. Eur J Clin Nutr. 54(6):453–459.

Hu FB. 2002. Dietary pattern analysis: a new direction in nutritional epidemiology. Curr Opin Lipidol. 13(1):3–9.
Landsberg B, Plachta-Danielzik S, Lange D, Johannsen M, Seiberl J, Muller MJ. 2010. Clustering of lifestyle factors and association with overweight in adolescents of the Kiel Obesity Prevention Study. Public Health Nutr. 13(10A):1708–1715.
Larson NI, Neumark-Sztainer DR, Harnack LJ, Wall MM, Story MT, Eisenberg ME. 2008. Fruit and vegetable intake correlates during the transition to young adulthood. Am J Prev Med. 35(1):33–37.
McNaughton SA, Ball K, Mishra GD, Crawford DA. 2008. Dietary patterns of adolescents and risk of obesity and hypertension. J Nutr. 138(2):241–248.
Michels KB, Schulze MB. 2005. Can dietary patterns help us detect diet-disease associations? Nutr Res Rev. 18(2):241–248.
Michels N, Vynckier L, Moreno LA, Beghin L, de la OA A, Forsner M, Gonzalez-Gross M, Huybrechts I, Iguacel I, Kafatos A, et al. 2018. Mediation of psychosocial determinants in the relation between socio-economic status and adolescents’ diet quality. Eur J Nutr. 57(3):951–963.
Moreno LA, Gonzalez-Gross M, Kersting M, Molnár D, de Henauw S, Beghin L, Sjöström M, Hagströmer M, Manios Y, Gilbert CC, et al. 2008. Assessing, understanding and modifying nutritional status, eating habits and physical activity in European adolescents: the HELENA (Healthy Lifestyle in Europe by Nutrition in Adolescence) Study. Public Health Nutr. 11(3):288–299.
Moreno LA, Gottrand F, De Henauw S, González-Gross M, Gilbert C, Kafatos A, Moreno LA, Libersa C, De Henauw S, Sánchez J, et al. 2014. Nutrition and lifestyle in European adolescents: the HELENA (Healthy Lifestyle in Europe by Nutrition in Adolescence) study. Adv Nutr. 5(5):615S–23S.
Moreno LA, Rodriguez G. 2007. Dietary risk factors for development of childhood obesity. Curr Opin Clin Nutr Metab Care. 10(3):336–341.
Neumark-Sztainer D, Story M, Perry C, Casey MA. 1999. Factors influencing food choices of adolescents: findings from focus-group discussions with adolescents. J Am Diet Assoc. 99(8):929–937.
O’Dea JA. 2003. Why do kids eat healthful food? Perceived benefits of and barriers to healthful eating and physical activity among children and adolescents. J Am Diet Assoc. 103(4):497–501.
Pinho MGM, Mackenbach JD, Charreire H, Oppert JM, Bardos H, Glonti K, Rutter H, Compernolle S, De Bourdeaudhuij I, Beulens JWJ, et al. 2018. Exploring the relationship between perceived barriers to healthy eating and dietary behaviours in European adults. Eur J Nutr. 57(5):1761–1770.
Rey-Lopez JP, Vicente-Rodriguez G, Biosca M, Moreno LA. 2008. Sedentary behaviour and obesity development in children and adolescents. Nutr Metab Cardiovasc Dis. 18(3):242–251.
Rokholm B, Baker JL, Sorensen TI. 2010. The levelling off of the obesity epidemic since the year 1999—a review of evidence and perspectives. Obes Rev. 11(12):835–846.
Santaliestra-Pasías AM, Mouratidou T, Huybrechts I, Beghin L, Cuenca-García M, Castillo MJ, Galfo M, Hallström L, Kafatos A, Manios Y, et al. 2014. Increased sedentary behaviour is associated with unhealthy dietary patterns in European adolescents participating in the HELENA study. Eur J Clin Nutr. 68(3):300–308.
Sawyer SM, Afifi RA, Bearinger LH, Blakemore S-J, Dick B, Ezeh AC, Patton GC. 2012. Adolescence: a foundation for future health. Lancet. 379(9826):1630–1640.
Stevenson C, Doherty G, Barnett J, Muldoon OT, Trew K. 2007. Adolescents’ views of food and eating: identifying barriers to healthy eating. J Adolesc. 30(3):417–434.
Story M, Neumark-Sztainer D, French S. 2002. Individual and environmental influences on adolescent eating behaviors. J Am Diet Assoc. 102(3 Suppl):S40–S51.
Tanner JM, Whitehouse RH. 1976. Clinical longitudinal standards for height, weight, height velocity, weight velocity, and stages of puberty. Arch Dis Child. 51(3):170–179.

The NS, Suchindran C, North KE, Popkin BM, Gordon-Larsen P. 2010. Association of adolescent obesity with risk of severe obesity in adulthood. Jama. 304 (18):2042–2047.

van der Horst K, Oenema A, Ferreira I, Wendel-Vos W, Giskes K, van Lenthe F, Brug J. 2007. A systematic review of environmental correlates of obesity-related dietary behaviors in youth. Health Educ Res. 22(2):203–226.

Vanhelst J, Beghin L, Drumez E, Duhamel A, De Henauw S, Ruiz JR, Kafatos A, Manios Y, Widhalm K, Mauro B, et al. 2018. 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. Public Health Nutr. 21(17):3192–3201.

Vereecken C, De Henauw S, Maes L, Moreno L, Manios Y, Phillipp K, Plada M, De Bourdeaudhuij I. 2009. Reliability and validity of a healthy diet determinants questionnaire for adolescents. Public Health Nutr. 12(10):1830–1838.

Vereecken CA, Covents M, Matthys C, Maes L. 2005. Young adolescents’ nutrition assessment on computer (YANA-C). Eur J Clin Nutr. 59(5):658–667.

Vereecken CA, Covents M, Sichert-Hellert W, Alvira JM, Le Donne C, De Henauw S, De Vriendt T, Phillipp MK, Béghin L, Manios Y, et al. 2008. Development and evaluation of a self-administered computerized 24-h dietary recall method for adolescents in Europe. Int J Obes (Lond). 32(Suppl 5):S26–S34.