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BREAKFAST HABITS AMONG EUROPEAN ADOLESCENTS

The Healthy Lifestyle in Europe by Nutrition in
Adolescence (HELENA) study

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To Peter

My breakfast-maker

ABSTRACT

The aim of this thesis was to study the associations of individual and socio-environmental factors with breakfast habits among adolescents on a European level.

Methods: The HELENA-study (Healthy Lifestyle in Europe by Nutrition in Adolescence) is a multi-centre cross-sectional, school-based study including 3528 adolescents (aged 12.5-17.49 years) from 10 European cities in Europe. Data was collected during the 2006-2007 academic year. Breakfast habits were assessed by a computerised, self-administered, 24-h recall and by questionnaires. The whole day dietary intake, measured with the computerised 24-h recall, was evaluated by comparing a self-administered and an interviewed 24-h recall. The socio-demographical factors used were sex, age, region in Europe (southern versus northern/central), mother and father's education and occupation, family structure and family affluence. Body composition was measured with weight, height, waist circumference and skinfold thickness. Blood pressure, cardiorespiratory fitness, blood lipids, insulin and glucose were also measured.

Results: The evaluation between the self-administered and interview 24-h recall showed generally good agreement between the two methods. Few adolescents (4 %) had a 'high-quality' breakfast. Breakfast consumption on both recall days was reported among 77 % (24-h recall) and 55 % reported slightly disagreeing to strongly disagreeing with the statement 'I often skip breakfast'. Younger adolescents, adolescents from the northern/central part of Europe and adolescents from families with high socio-demographical status were more likely to report consuming a 'high-quality' breakfast while breakfast consumption versus breakfast skipping were inappreciably associated with socio-demographical factors. Personal factors ('hunger', 'taste of the food' 'concern for health') and the socio-environmental factor ('parents or guardian') were the most important influences on the adolescents' choice of food at breakfast. Regular 'breakfast consumption' was associated with higher cardiorespiratory fitness in both boys and girls, and with a healthier cardiovascular profile, especially in boys.

Conclusion: The public health implications of poor breakfast consumption habits are considerable. This work highlights the need to promote breakfast, especially a 'high-quality' breakfast, among adolescents, particularly older adolescents, adolescents from the southern part of Europe and adolescents from families with low socio-demographical status.

Keywords: Breakfast; adolescents; socio-demographical factors; dietary assessment; 24-h recall; food groups; cardiovascular disease risk factors; Europe

LIST OF PUBLICATIONS

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LIST OF ABBREVIATIONS

BMI	Body mass index
CVD	Cardiovascular disease
Dias BP	Diastolic blood pressure
FAS	Family affluence scale
HBSC	Health Behaviour in School-aged Children
HDLc	High-density lipoprotein cholesterol
HELENA	Healthy Lifestyle in Europe by Nutrition in Adolescence
HOMA	Homeostasis model assessment
LDLc	Low-density lipoprotein cholesterol
Sys BP	Systolic blood pressure
TC	Total cholesterol
TG	Triglycerides
VO ₂ max	Maximum oxygen consumption
WC	Waist circumference
YANA-C	Young Adolescents' Nutrition Assessment on Computer

1 BACKGROUND

1.1 Breakfast from a historical perspective

The importance of consuming breakfast has been known for a long time. Already in the end of the nineteenth century North American scientists were discussing the American breakfast. At that time, they believed that Europeans broke the overnight fast with a light meal while the Americans consumed a large meal. The discussion centred on which was better. The order of serving the food in a big breakfast was also discussed. The American scientists suggestion was to start the breakfast meal with cereals, then potato, followed by meat or eggs and ending with fruits and coffee (Boardman, 1898).

In the beginning of the twentieth century, Hollopeter in the USA wrote that many children and adolescents went to school hungry. Breakfast was omitted or insufficient in quantity and/or poor in quality, and this problem was not confined to just the poorer classes. The reasons children gave was that they did not want breakfast or that their mother could not make it (Hollopeter, 1909).

The Iowa Breakfast Study in the USA, in the end of 1950s, was one of the first studies that pointed out the importance of consuming breakfast (Cereal Institute, 1957). The study addressed the role of breakfast in improving academic performance and dietary balance for children and adolescents.

During the 1960s experimental breakfast studies were performed both in Europe (Arvedson et al., 1969) and in the USA (Ohlson and Hart, 1965, Thornton and Horvath, 1965). Later school breakfast programs started to be widespread in Europe (Bender et al., 1977) and in the USA (Stewart, 1973, Gordon et al., 1995, Kleinman et al., 2002), in order to serve adolescents a healthy breakfast before school. Participation in those breakfast programs was shown to result in a better daily nutrient intake. An interest in the importance of the home-food-environment began to be seen in the scientific literature during the 1990s (Glanz, 2009).

More recently, studies have shown that adolescents, in western countries, consuming breakfast perform better in school (Rampersaud et al., 2005, Taras, 2005, Kleinman et al., 2002, Lien, 2007) and have a nutrient intake closer to nutritional recommendations (van den Boom et al., 2006, Utter et al., 2007).

1.2 Definitions of breakfast

Breakfast is defined, according to one dictionary, as the first meal in the morning (Walter, 2005). In the scientific literature, the definitions of breakfast are not consistent and vary between ‘the first thing you eat from the moment you wake up in the morning until the moment you start eating lunch’ (Dialektakou and Vranas, 2008); ‘the first eating occasion involving a solid food or a beverage that occurred after waking’ (Matthys et al., 2007); ‘the intake before school’ (Sjöberg et al., 2003); ‘any intake of food or beverage between specific times in the morning’ (Vanelli et al., 2005).

A variety of definitions are also used to describe ‘breakfast consumers’: people who ‘consume breakfast every day’; ‘every school day’; ‘on the dietary survey day’; ‘on a minimum number of days per week’ or who ‘usually’ or ‘habitually’ consume breakfast (Rampersaud et al., 2005, Szajewska and Ruszczynski, 2010). ‘Breakfast skippers’ are, unsurprisingly, also defined in various ways: people who ‘skip breakfast on the dietary survey day’; who ‘usually skip breakfast’; who ‘skipped breakfast more than three times the previous week’; who ‘never or almost never consume breakfast’ (Rampersaud et al., 2005, Szajewska and Ruszczynski, 2010). According to EUFIC (The European Food Information Council) most countries in Europe have developed their own ‘Food based dietary guidelines’ and they suggest that if consumers choose foods from the main groups (‘milk and dairy products’, ‘cereals’, ‘fruits and vegetables’ and ‘meat, fish and eggs’) each day, an important first step is taken towards achieving a healthy diet, without the need for specific knowledge of nutrients. There are no special recommendations for breakfast (EUFIC, 2011).

A study from the Netherlands (Raaijmakers et al., 2010) included products from the five food groups ‘fruit/fruit juice’, ‘grain’, ‘dairy’, ‘fat’ and ‘liquid’ and defined it as ‘high quality breakfast’ (Raaijmakers et al., 2010). Others have defined a ‘high quality breakfast’ if (relevant amounts of) three food groups (‘cereal’, ‘dairy’ and ‘fruit/vegetables’) are present (Aranceta et al., 2001, Matthys et al., 2007, van den Boom et al., 2006). According to the literature, breakfast should preferably consist of products from at least those three food groups (Giovannini et al., 2008).

The different definitions in the literature of ‘breakfast’, ‘breakfast consumers’ and ‘breakfast skippers’ make comparisons between studies difficult. One example of a clear definition of breakfast is provided by Timlin and Pereira (2007), who suggested that breakfast should be defined as “the first meal of the day, eaten before or at the start of daily activities within 2 hours of waking, typically no later than 10.00 am, and of a

calorie level between 20 % and 35 % of total daily energy needs' (Timlin and Pereira, 2007). This definition has also been discussed in a symposium about breakfast and it has been suggested that for reason of comparability research is needed in order to produce common definitions for use in breakfast studies (Giovannini et al., 2010).

1.3 Assessment of dietary intake

Choosing a method to assess dietary habits in a population depends on the characteristics of the subjects within the study population, the expected outcomes and the objectives of the study. Assessing dietary habits is difficult due to the complexity of dietary habits.

In epidemiological dietary surveys, three methods are commonly used: food records, food frequency questionnaires (FFQ) and 24-h recalls. A food record is a descriptive method to collect dietary information prospectively, normally executed for 1-7 days. The FFQ is a retrospective survey and asks about the usual food intake for a specific time period and the focus can be on particular food groups or on total food intake. The 24-h recall (twenty-four-hour recall) is a retrospective interview method concerning intake on the day before the interview (Gibson, 2005). Besides these methods to assess dietary intake, questionnaires are used to assess food behaviours, meal intakes etc. The 24-h recall dietary method, will be described in more detail.

The aim of a 24-h recall is to describe the nutritional intake both qualitatively and quantitatively. The traditional way a 24-h recall is performed is that a nutritionist/dietician trained in interviewing techniques asks the participants in detail about the food intake during the previous 24-hour period or preceding day. The interview can be done on one occasion or repeated, and it is recommended to have weekend days proportionately included in the study. One interview technique for the 24-h recall is the four stage multiple-pass technique. The first stage is to complete a list of all food and beverages consumed for the recalled period. The second stage is to ask in more detail about cooking methods and brand names. The third stage is to ask for the amount of each food consumed and the interviewer often shows photographs and/or models of food and/or household utensils. If a telephone interview is performed, photographs of food items and household utensils are usually sent home before the interview. The fourth stage is to review the information to ensure the validity (Gibson, 2005).

1.3.1 Dietary assessments among adolescents

When adolescents are the target group in dietary surveys many aspects have to be taken into consideration. Livingstone and Robson reported that adolescents' food habits are rapidly changing, and display less structured eating patterns, more out-of-home eating, less supervision by adults and more influence by peers (Livingstone and Robson, 2000) than children's habits do. These circumstances and a frequent lack of willingness to participate in dietary surveys (Livingstone et al., 2004) make the tool chosen to measure dietary habits important. A successful instrument to measure dietary habits among adolescents needs to be short, easily administered, accurate and practical (Rockett et al., 2003). Adolescents are open-minded about adapting new technology. Computer- and cell phone administered dietary assessment tools are a growing area and are technically, financially and practically feasible (Moore et al., 2008, Rockett et al., 2003). Cell phones for food record (Boushey et al., 2009) and computerised 24-h recall have both been used for adolescents (Vereecken 2005) and for children (Baranowski et al., 2002, Moore et al., 2005)

1.3.2 Reliability and validity in dietary surveys

Reliability is the agreement between measurements on different occasions and validity is the measurement's ability to measure the right thing. If reliability is measured in dietary surveys, 'test-retest' is the method used and it can only ever be estimated because replicate observations in dietary assessment, at different times, are impossible (Gibson, 2005). Even if the results from two separate dietary surveys differ, the methods may not have poor reliability because within-subject variations can be rather high (Nelson et al., 1989). It is also important in dietary surveys to take into account between-subject variations, seasons, weekdays, population groups, nutrients of interest and the technique used to measure the food and quantities consumed (Gibson, 2005). The reproducibility of 24-h recalls on group level is relatively high, if days from all parts of the week are included (Rasanen, 1979).

The 'golden standard' in dietary surveys to validate reported energy intake is the 'doubly labelled water' method (Coward, 1991, Gibson, 2005) but the method is expensive. Weighed records are appropriated, but estimated records are common for practical reasons (Gibson, 2005). Other validation methods used include; measuring the protein content by biomarker (urinary nitrogen excretion) (Isaksson, 1980, Bingham and Cummings, 1985) for comparison with protein intake; comparing energy intake

with estimated basal metabolic rate (calculating ‘Goldberg cut-offs’ from energy intake) (Black, 2000a, Goldberg et al., 1991) and calculating energy expenditure from physical activity data and comparing it with energy intake (Black, 2000b).

1.4 Breakfast habits among European adolescents

Breakfast is one of the most-studied meals (Giovannini et al., 2010), but what is known about breakfast habits among adolescents in Europe?

The development of autonomy during adolescence is complex and dependency appears to shift from parents to peers. Girls show more autonomy in all ages compared to boys (Steinberg and Silverberg, 1986). Adolescents are often tired in the morning and time spent asleep declines, bedtimes are often delayed and differences in sleeping habits between weeknights and weekends increases (Carskadon, 1990). These puberty-related variations in circadian rhythm might influence breakfast habits (Nordlund, 2004). A consequence can be that they skip breakfast (Utter et al., 2007, Lien, 2007, Temple et al., 2006).

The Health Behaviours in School-aged Children study (HBSC), which is an international network of research teams across Europe and North America, reported that daily breakfast consumption among European adolescents ranges from 33 % (Greek girls) to 75 % (Portuguese boys) (Vereecken et al., 2009b). Breakfast skipping has also been shown to vary from 2 % among Greek girls (Dialektakou and Vranas, 2008) to 39 % among Dutch girls (Croezen et al., 2007).

Daily breakfast consumption decreases by age among most of the European countries in the HBSC study (Vereecken et al., 2009b). Similar results have been shown among Dutch adolescents (Croezen et al., 2007, Raaijmakers et al., 2010). Johansen (2006) showed no age decline in breakfast consumption among Danish adolescents. Girls, in the HBSC study, were less likely to be daily breakfast consumers than boys in most of the European countries (Vereecken et al., 2009b). Adolescents from Norway (Lien, 2007), Denmark (Johansen et al., 2006) and the Netherlands (Croezen et al., 2007, Raaijmakers et al., 2010) showed the same sex differences in regular breakfast consumption, while a study among adolescents from Portugal reported no sex differences (Mota et al., 2008).

Regular breakfast consumption among Danish adolescents was positively associated with mothers being employed (Johansen et al., 2006). High parental education has also been associated with regular breakfast consumption among

Norwegian adolescents (Lien, 2007). The HBSC study measured socio-economic status as family affluence and showed regional differences, between the European countries, in the association with daily breakfast consumption (Vereecken et al., 2009b).

European adolescents from two-parent families were more likely to be daily breakfast consumers compared to adolescents from single-parent families, with the exception of adolescents from east Europe (Vereecken et al., 2009b). Similar results have been shown among Danish adolescents (Johansen et al., 2006).

Milk and cereals for breakfast are commonly reported across various child and adolescent populations in western countries (Rampersaud et al., 2005), while fruit is less common (Aranceta et al., 2001, Raaijmakers et al., 2010).

A ‘good-quality’ breakfast was found to be consumed by about 10 % of Belgian adolescents (Matthys et al., 2007), and similar results were reported among Dutch (Raaijmakers et al., 2010) and Spanish adolescents (van den Boom et al., 2006).

A ‘good-quality’ breakfast has also been shown to be associated with a better overall dietary pattern (Matthys et al., 2007, Raaijmakers et al., 2010, Sjöberg et al., 2003), with better mental health (O’Sullivan et al., 2009), with a positive effect on cognitive function (Wesnes et al., 2003) and with a decreased risk of developing obesity and type 2 diabetes (Pereira et al., 2011).

Utter et al. have shown that New Zealand children/adolescents who consumed breakfast regularly were more likely to frequently consume dairy products, fruit and cereals on a daily basis in comparison to irregular breakfast consumers (Utter et al., 2007).

1.5 Factors influencing dietary habits

Dietary habits are complex and result from the interplay of multiple influences. Story et. al have described an ecological framework from the ‘Social Cognitive Theory’ for conceptualizing food environments and their influences on food choices (Story et al., 2008). There are four levels of influence; individual, social-, physical- and macro-level environments all interact and affect the dietary habits.

The individual level is related to food choices and eating behaviours and includes cognitions, behaviours, and biological and demographic factors. These individual factors can impact food choices through characteristics such as motivation, self-efficacy, outcome expectations, and behavioural capability.

The socio-environmental includes interactions with family and peers. This level may impact food choices through mechanisms such as social encouragement, modelling and norms.

The physical environment includes where food is produced, bought or consumed such as home, school, restaurant or supermarket. This level impacts availability and opportunities to choose food.

The macro-level environments have a more indirect role, but have a powerful effect on what people consume. This level includes social norms, food production and economic food policies. To work with health promotion among adolescents it is important to take into consideration all these levels (Story et al., 2008).

Studies about factors influencing food choices among adolescents in Europe are scarce. Two Swedish studies have reported that taste seems to be more important than health in food choices among adolescents (Berg et al., 2003, Lennernas et al., 1997). Keski-Rahkonen et al. showed, among Finnish adolescents, that breakfast consumption was much more influenced by the family and the environment among girls than it was in boys (Keski-Rahkonen et al., 2003).

1.6 The association of breakfast with body fat and risk for cardiovascular diseases

Because the prevalence of overweight and obesity has been increasing in developed countries over the past two decades (EASO, 2010), it is important to identify factors that are associated with the rising obesity epidemic. Figure 1 show the prevalence of obesity/overweight among European children/adolescents.

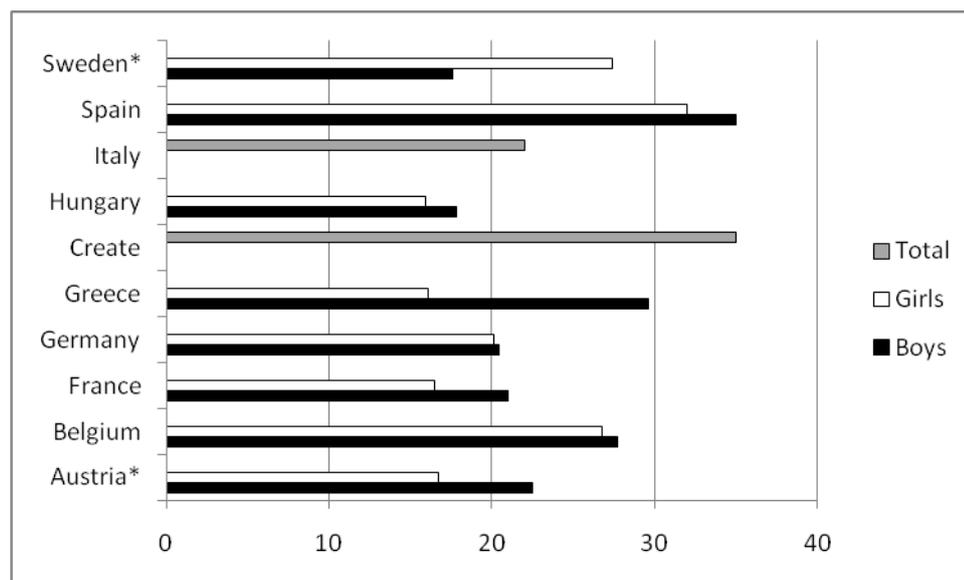


Figure 1: The prevalence of obesity/overweight in European countries among adolescents (the data are measured between 1998 to 2008) (EASO, 2010).

*Measured on pre adolescents (6-12 years of age)

The mechanisms between breakfast and body composition and cardiovascular diseases are complex (Timlin and Pereira, 2007). Meal skipping, in particular breakfast skipping is associated with appetite dysregulation and skipping breakfast may lead to increased appetite (Pereira et al., 2011). Meal frequency appears to be involved in the regulation of glycaemia, insulinaemia and lipid metabolism (Timlin and Pereira, 2007). A regular meal pattern may reduce the risk of developing of overweight and obesity. Several studies have shown a positive relationship between breakfast skipping and overweight/obesity in adolescents (Dubois et al., 2009, Rampersaud et al., 2005, Szajewska and Rusczyński, 2010, Merten et al., 2009). A ‘high quality’ breakfast has also been associated with factors related to appetite control, blood sugar and insulin levels among children and adults (Pereira et al., 2011). Regular breakfast consumption is associated with improved diet quality and

better food choices throughout the day (Matthys et al., 2007). Both the frequency and the quality of breakfast may be important in the fight against obesity.

Figure 2 illustrates a theoretical model of how breakfast frequency and quality could be involved in the prevention of obesity and chronic diseases. The theoretical background of the model is that breakfast skippers may have impaired regulation of appetite and that might lead to weight gain over time. Breakfast skipping has also been linked to poorer overall dietary quality (van den Boom et al., 2006, Utter et al., 2007). Regularly consuming breakfast, especially consuming cereals, is associated with a lower BMI (Barton et al., 2005). The mechanisms, behind consuming breakfast, hypothesized to reduce appetite and subsequently chronic disease risk (Timlin 2007).

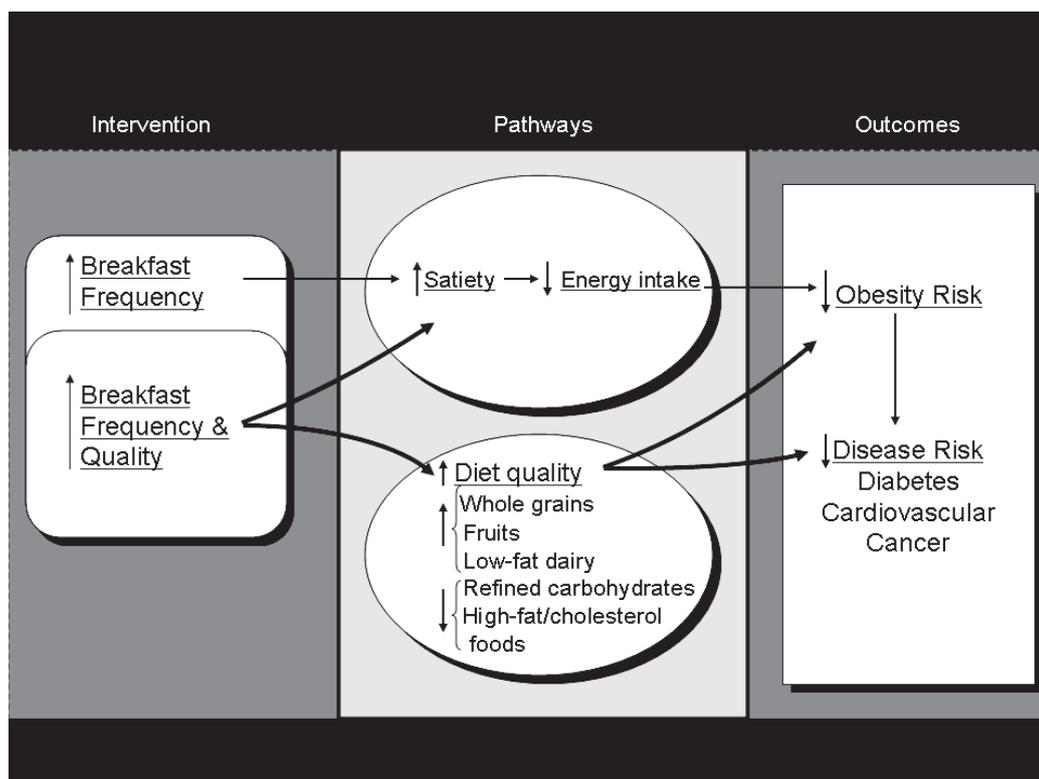


Figure 2: Theoretical model of how breakfast frequency and quality could be associated with the development of obesity and chronic diseases. Reproduced with permission from John Wiley and Sons (Timlin 2007).

1.7 Relevance of this thesis

To facilitate health promotion it is important to establish policies and environments that support health behaviours. There is increasing evidence that socio-environmental and individual factors are associated with breakfast habits among adolescents, but harmonised and standardised data among adolescents on a European level are scarce.

The Healthy Lifestyle in Europe by Nutrition in Adolescents (HELENA) cross-sectional study was established to assess lifestyle habits and their association with nutrition, to identify risk factors for eating disorders, dyslipidemia, obesity and/or type 2 diabetes in a wide range of EU countries, and to describe regional, cultural, social, genetic and sex differences and similarities across Europe.

This thesis presents the association of individual and socio-environmental factors with breakfast habits among adolescents on a European level. This will give a comprehensive picture of breakfast habits among European adolescents and serve as a basis for future research in this topic.

2 AIM OF THE THESIS

The overall aim of this thesis was to study the associations of individual and socio-environmental factors with breakfast habits among adolescents on a European level, but first the development and feasibility of a computerised 24 hour recall will be described.

- I To describe the development of a European computerized 24-h recall method for adolescents, and to investigate the feasibility of self-administration (self report) by comparison with administration by a dietician (interview).
- II To describe breakfast habits on food group level in European adolescents and to investigate the associations between habits and socio-demographical factors such as sex, age, region in Europe, maternal and paternal education, family structure and family affluence.
- III To investigate factors influencing the food European adolescents choose for breakfast. Additionally, association with socio-environmental variables were investigated so that better tailored interventions to promote breakfast could be developed in the future.
- IV To examine the association between breakfast consumption (skipper, occasional consumers and consumers) and cardiovascular disease (CVD) risk factors including body mass index, skinfold thickness, waist circumference, cardiorespiratory fitness, blood pressure, blood lipids and insulin resistance in European adolescents. We also studied the interaction between breakfast consumption and weight status on CVD risk factors.

3 MATERIAL AND METHODS

3.1 Study design

The HELENA-study (Healthy Lifestyle in Europe by Nutrition in Adolescence) is a multi-centre cross-sectional, school-based study (HELENA, 2005, Moreno et al., 2008). The main aim of HELENA is to obtain reliable and comparable data of a representative sample of European adolescents. The HELENA-study has measured dietary intake, nutrition knowledge, eating attitudes, food choices, preferences, body composition, plasma lipids, metabolic profile, vitamin status, immune function related to nutritional status, physical activity, fitness and genotype. The study includes 3528 adolescents (aged 12.5-17.49 year) from 10 European cities with more than 100 000 inhabitants in Europe; Athens in Greece, Dortmund in Germany, Ghent in Belgium, Heraklion in Greece, Lille in France, Pecs in Hungary, Rome in Italy, Stockholm/ Västerås in Sweden, Vienna in Austria and Zaragoza in Spain (Figure 3). Data was collected during the 2006-2007 academic year.

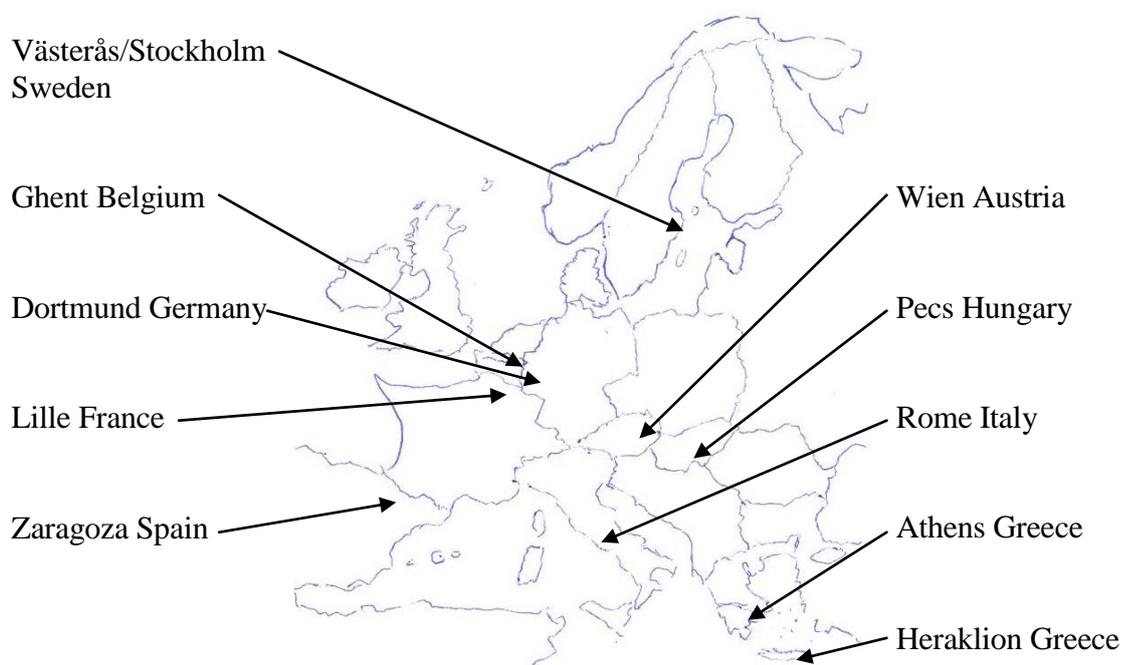


Figure 3: Map of Europe with the included cities

3.1.1 Selections of participants

The cities were chosen for practical reasons rather than randomly (Moreno et al., 2008). The criteria to choose those cities were that they were spread geographically, had different cultures and socio-economical situations and the HELENA partners were based in those cities. A two-stage cluster procedure was made in each of the cities to recruit the participants. The school population in the age group 13.0-16.99 was intended to be the total population, because it was compulsory to attend school at those ages in all the participating countries. Each centre made up a list of all schools and classes in the chosen age group. The schools were divided into geographical districts according to the community's normal grouping, private schools were marked on the list (at least one of the private schools was supposed to be randomly selected). Schools were randomly selected within each stratified group and invited to participate. In a second step, classes (in predefined age groups) from the selected schools were randomly selected. Detailed descriptions of study design, sampling and procedure have previously been published (Moreno Aznar, 2005, Moreno et al., 2007, Moreno et al., 2008). The response rate for the schools and classes differed between countries (with Austria having the lowest participation rate (57 % of schools) and France the highest (92 % of schools)). The participation rate for pupils within the participating classes also differed between countries (France having the lowest and Germany the highest). A class was considered eligible if the participation rate was at least 70 %.

The statistical power for the study was calculated based on a confidence level of 95 % and a worst-case scenario ± 0.3 error for body mass index (BMI). This was the variable with the greatest variance in the given population in regard to the variables that is going to be studied. Two studies on adolescents were used to calculate the means and standard deviation for BMI (Moreno et al., 2006, Cacciari et al., 2002). The number of adolescents per centre that would participate in the study, was estimated at 300. A group of 1000 adolescents (100 from each centre) were randomly selected for blood tests. The reason why a subgroup was chosen, and not the total group, was because the blood parameters have less variability and a smaller group was sufficient to be representative (Gonzalez-Gross et al., 2008).

All adolescents in the selected classes could participate in the study but in the final database the inclusion criteria were that the subject:

- Was aged between 12.5 and 17.49 years
- Had informed consent signed
- Had weight and height measured

Exclusion criteria were that the subject:

- Participated simultaneously in another research trial
- Had an acute infection less than one week before the test

3.1.2 Harmonisation and standardisation of the methods

The fieldwork was done after strict standardised manuals and manuals of operation had been made for all the different measurements (Vereecken et al., 2008, Ortega et al., 2008a, Kersting et al., 2008, Iliescu et al., 2008, Hagstromer et al., 2008, Gonzalez-Gross et al., 2008, Nagy et al., 2008). All included centres had at least one fieldworker, who collected data for the whole study in the respective city. To harmonise the methodologies, training workshops, for the fieldworkers were held over three weeks, one in Zaragoza (Spain), one in Pécs (Hungary) and one in Athens (Greece).

All the questionnaires were translated into the local language and back-translated to English and checked for similarity and divergence. The processing of questionnaires was carried out centrally in Ghent. All blood samples were analysed centrally in Bonn (Gonzalez-Gross et al., 2008).

3.1.3 Ethics

Both parents and adolescents gave written informed consent, and the study was approved by the national or local independent Ethics Committee from the relevant European city (Beghin et al., 2008). The boards of all collaborating schools approved the use of school localities during school hours. The regional ethical board in Stockholm (Regionala etikprövningsnämnden i Stockholm) (permit no. 2007/70-31/2) granted ethical permission for the Swedish part of the study.

3.1.4 Overview of this thesis

This thesis includes four papers.

Table 1: Overview of this thesis including the four papers and their population, methods and statistical analysis.

Paper	I	II	III	IV
Design	Cross sectional study			
Population	N=2850 8 cities (Heraklion and Pecs excluded)	N=3244 9 cities (Heraklion excluded)	N=3528 N=1089 blood sample 10 cities	
Population in the paper	N=236 (subsample from the main study (8%))	N=2672 (82% who completed the 24-h recall on two days)	N=2929 (83% who responded to the breakfast statement)	
Method	<ul style="list-style-type: none"> • Food groups and nutrient from computerised 24-h recall (YANA-C) one day • Comparing self-report and interview 	<ul style="list-style-type: none"> • Food groups from 24-h recall (YANA-C) • Questionnaires <ul style="list-style-type: none"> • YLE^b 	<ul style="list-style-type: none"> • Questionnaires <ul style="list-style-type: none"> • FCP^a • YLE^b • HE^c 	<ul style="list-style-type: none"> • Questionnaires <ul style="list-style-type: none"> • FCP^a • YLE^b • Anthropometry • Blood sample • Blood pressure • Cardio respiratory fitness
Analysis	<ul style="list-style-type: none"> • Wilcoxon signed rank test • Spearman correlation • Bland Altman • Kappa 	<ul style="list-style-type: none"> • Logistic regression • Multiple linear regression 	<ul style="list-style-type: none"> • Logistic regression 	<ul style="list-style-type: none"> • Chi-Square • One-way ANCOVA • Two-way ANCOVA
^{a)} FCP - Food Choices and Preferences ^{b)} YLE – Your Living Environment ^{c)} HE – Healthy diet determinants				

3.2 Measurements

3.2.1 Dietary assessments

3.2.1.1 Computerised 24-h recall

The computerised 24-h recall method, Young Adolescents' Nutrition Assessment on Computer (YANA-C) was self-administered. The program was developed in Belgium and was culturally adapted and translated for use in all the involved countries (Vereecken et al., 2005a, Vereecken et al., 2008). Two 24-h recalls, were performed using the YANA-C, on two non-consecutive days, within two weeks. The YANA-C was filled in by the adolescents in the school's computer room or in the class room with laptops, and it took about 10-30 minutes.

YANA-C was built up round six meal occasions (breakfast – morning snacks – lunch – afternoon snacks – evening meal – evening snacks). To help the adolescents to remember their intake, the program asked questions both before and after they selected the food items. Pictures and measurement units helped the adolescents to give quantitatively detailed information of the food they had consumed, which has been shown to be a good aid in ranking individuals (Vereecken et al., 2010).

All food items in the YANA-C have been classified into 29 food groups based on the European Food Group classification system (Ireland et al., 2002) and reduced to 17 food groups in Paper II (Table 2).

Table 2: Food groups used in this thesis.

Original food groups in YANA-C, Paper I	Food groups in Paper II
Breakfast cereals	Breakfast cereals
Bread rolls and flour	Bread
Sweet bakery products	Cakes, pies, biscuits and snacks
Savoury snacks	
Sugar, jam, syrup	Added sugar
Confectionery	Sweets including chocolate
Chocolate	
Fat	Added fat/oil (butter and vegetable fat)
Nuts, seeds, olives	
Pulses, vegetables	Fruits and vegetable
Starch roots, potatoes	
Fruits	
Juices	Fruit juice
Water	Water
Coffee, tea	Tea, coffee
Carbonated soft drinks	Soft drink
Alcoholic beverages	Not relevant
Meat, meat products	
Fish, fish products	Meat, fish, eggs and their products
Eggs	
White milk, buttermilk	Milk, yoghurt and soya drinks
Yoghurt, quark	
Cheese	Cheese
Milk and yoghurt beverages	Other milk products
Creams, milk-based desserts	
Pasta and rice	
Miscellaneous	Miscellaneous
Sauces	
Soups	

To investigate the feasibility of the computerised 24-h recall, YANA-C, data from the self-administered YANA-C was compared with data from an interviewer-administered YANA-C. The adolescents completed the self-administered YANA-C in the morning and, later on the same day, the interview took place with a researcher with nutritional knowledge behind the computer. The interviewer was allowed to ask extra questions or give extra explanation in order to select the correct food items and amounts. At the end of the YANA-C program an overview screen was shown and the question was again asked about whether something was forgotten.

Total energy and nutrient intakes (carbohydrates, protein, fat, fibre, calcium, iron and ascorbic acid) were calculated using country-specific nutrient composition databases. Food groups were categorised into different groups depending on amount and if they were consumed on one or both of the recall days.

3.2.1.2 Questionnaires about dietary habits

The questionnaires about food-related issues used in this thesis were: ‘Food Choices and Preferences’ (Gilbert et al., 2008) and ‘Healthy Diet Determinants’ (Vereecken et al., 2009a).

3.2.1.2.1 Food Choices and Preferences questionnaire

The ‘Food Choices and Preferences’ (FCP) questionnaire was developed based on the results of 44 focus groups (with 304 adolescents) (Gilbert et al., 2010) which explored attitudes and issues of concern amongst adolescents regarding food choices, preferences, healthy eating and lifestyles. The focus groups were conducted in five European countries (Belgium, Hungary, Spain, Sweden and UK) and the adolescents that took part were not sampled as part of the main HELENA study. Information was gathered regarding eating habits at various meal occasions; factors that influence food choice; favourite foods, healthy foods and traditional foods; healthy lifestyle and physical activity; sources of information on healthy eating and lifestyle; and exploration of ideas for new product development. This provided insight into aspects such as snacking, the perceived importance of 'health' in influencing choices, and barriers to healthy eating (Gilbert et al., 2008).

The questionnaire included the statement ‘I often skip breakfast’ with seven possible answers ranging from strongly disagree to strongly agree (for more detail see section. 3.2.1.3). The adolescents were also asked questions about influencing factors. ‘How strong of an influence do the following factors have on your choice of foods at breakfast?’ This question were used for both personal factors (hunger, taste, health, daily routine, ease of preparation, medical reason and price) and socio-environmental factors (parents or guardian, friends, availability, and school environment) with five answer categories ranging from no and slight influence to moderate, strong and very strong influence.

The test-retest stability of the breakfast question was measured in 73 adolescents (55 % girls) in Belgium (not included in the HELENA Study), with a mean age of 13.2 years (SD 0.8). Kappa values were calculated. The dichotomized breakfast statement “I often skip breakfast’ showed good agreement between the test and retest (0.91) and the kappa values of the dichotomized factors (socio-environment and personal factors), ranged from medium to good agreement (0.35-0.75, $p < 0.01$ for the lowest correlation) with an average of 0.51.

3.2.1.2.2 Healthy Diet Determinants questionnaire

The 'Healthy Diet Determinants' questionnaire (Vereecken et al., 2009a) included assessments about socio-environmental factors 'How healthily does your father/mother/brother/sister/best friend eat?' and 'How often does your father/mother/brother/sister/best friend encourage you to eat a healthy diet?'. The questions had five answer categories ranging from very unhealthy to very healthily and not at all to very often. The questions are categorised into 'Parents' (father/mother) and 'Peers' (brother/sister/best friend).

The test-retest stability was measured in 55 adolescents (44 % girls), with a mean age of 14.6 (SD 1.1) years. The test-retest stability of the socio-environmental factors was poor to good (0.31-0.89) with Cronbach's α (peers' behaviour 0.31, peers encouragement 0.67, parents' behaviour 0.72 and parents' encouragement 0.89). Spearman's rank correlations were calculated between the socio-environmental factors (peers' behaviour, peers' encouragement, parents' behaviour and parents' encouragement) and the subjects' consumption of food groups: fruit, vegetables, soft drinks, snacks, non-sweetened milk. The correlations were good between parents' perceived behaviour and milk consumption ($r = 0.31$) and between peers' perceived behaviour and fruit ($r = 0.27$), vegetables ($r = 0.35$), snacks ($r = -0.28$) and soft drink consumption ($r = -0.30$) but non-significant for the remaining associations (Vereecken et al., 2009a).

For the purpose of the questionnaire, a 'healthy diet' was defined for the adolescents as: 'a well-balanced diet which contains a lot of fruit, vegetables and dairy products, a good portion of starchy foods like bread, potatoes and pasta, a moderate portion of meat or fish, and not too much fat and sugar. Also the intake of a large amount of fluid is very important in a healthy diet. The energy content of a healthy diet is in accordance with the needs of the human body' (Vereecken et al., 2009a).

3.2.1.3 Breakfast assessment

Breakfast was assessed through two different methods: the computerised 24-h recall (described in section 3.2.1.1) and their response to the statement: ‘I often skip breakfast’ from The ‘Food Choices and Preferences’ questionnaire (described in section 3.2.1.2.1). The concept of ‘breakfast’ in both methods was interpreted by the adolescents themselves (i.e. no definition was provided).

The computerised 24-h recall was built up round meal occasions and had questions that helped the adolescents to remember what they eat. The first two questions asked about the time they got up the previous day and if they had breakfast. If they responded no, they were asked an additional question ‘You didn’t have anything, however small, to eat or drink for breakfast?’. If the adolescents had breakfast, a drink or something small, they were asked ‘Where and with whom did you have breakfast yesterday?’ and ‘Around what time was that?’ Then, adolescents selected the food items consumed from a culturally adapted list and further described the quantity consumed.

Based on breakfast consumption the adolescent was classified as a ‘breakfast consumer’ (consumed breakfast on at least one recall day) or a ‘breakfast skipper’ (did not consume breakfast on either of the two recall days). According to one previous report (Alexy et al., 2010), a breakfast meal should weigh more than 15 grams to be considered as a meal. In our study five breakfast meals weighed less than 15 grams and they were counted into the group ‘not consuming breakfast on that actually day’.

Qualitative aspects of breakfast were related to the consumption of food items of three specific target food groups: cereal products, dairy products and fruit/vegetables (Giovannini et al., 2008). Every single breakfast from the two recall days was given one extra point for each of the included target food groups. The ‘breakfast index’ was categorised into eight groups; ‘skipper’, ‘no target food groups’, and one to six target food groups (three target food groups over two days).

The other method of measuring breakfast was via the statement: ‘I often skip breakfast’ from The ‘Food Choices and Preferences’ questionnaire (more detail in section 3.2.1.2.1). The statement had seven possible answers ranging from strongly disagreeing to strongly agreeing. From the answer on the statement the adolescents were categorised into three groups: (i) ‘breakfast consumers’; (ii) ‘occasional consumers’; and (iii) ‘breakfast skippers’.

3.2.2 Physical examination

3.2.2.1 Body composition

Weight was measured with an electronic scale (SECA 861). Light indoor clothing could be worn, excluding shoes, long trousers and sweater. The weight of the clothing was not subtracted from the observed weight. Weight was recorded to the nearest 100 grams.

Height was measured with a telescopic height measuring instrument (SECA 225). The adolescent stood on the stadiometer with bare feet placed slightly apart and the back of the head, shoulder blades, buttocks, calves, and heels touching the vertical board. Legs were kept straight and the feet flat. The observer positioned the adolescent's head such that a horizontal line drawn from the ear canal to the lower edge of the eye socket ran parallel to the baseboard (i.e., the Frankfort plane positioned horizontally). The headboard was pulled down to rest firmly on top of the head and compressed the hair and the reading was taken to the last completed 1 mm (Nagy et al., 2008)

BMI was calculated as body mass (kg) divided by height (m) squared. Adolescents were classified as non-overweight and overweight/obese according to Cole (Cole et al., 2000).

Waist circumference was measured with an anthropometric non-elastic tape (SECA 200). The adolescent stood erect with the abdomen relaxed, the arms at the sides and the feet together. The measurer faced the adolescent and placed an inelastic tape around the adolescent, in a horizontal plane, at the level of the natural waist, which is the narrowest part of the torso (at the midpoint between the superior iliac spine and the costal edge in the midaxillary line), as seen from the anterior aspect. Waist circumference was measured to the nearest 0.1 cm in triplicate (Nagy et al., 2008).

Skinfold thickness were measured with a Holtain Caliper (Crymmych, UK). A skinfold consists of a double fold of skin and subcutaneous fat, excluding the underlying muscle. For measurement of biceps, triceps, subscapular, suprailiac and thigh skinfold thickness the adolescent stood. For the measurement of the medial calf skinfold, the adolescent sat with knees on the side to be measured flexed to about 90°, with the sole of the corresponding foot on the floor. Skinfold thickness were measured, on the non-dominant side of the adolescent, to the nearest 0.2 mm (Nagy et al., 2008).

3.2.2.2 Pubertal stage

Pubertal stage was recorded by a researcher of the same sex as the child, according to Tanner and Whitehouse (Tanner and Whitehouse, 1962). The Tanner classification system is divided into five development stages; for girls it is based on breast and pubic hair development and for boys on genital and pubic hair development (Brook and Hindmarsh, 2001, Tanner and Whitehouse, 1976). The first Tanner stage of breast development for girls has the following description in the HELENA technical instructions in the HELENA study ‘The infantile stage persists from the immediate postnatal period until the onset of puberty. The breast has no glandular tissue and the areola and papilla conform to the chest line’ and stage five is described as: ‘This is the typical adult stage with a smooth rounded contour, the secondary mound present in stage 4 having disappeared’.

For boys, penis and scrotum development are estimated and stage one is described as follows: ‘During this time the genitalia increase in overall size, but there is little change in general appearance. Testes volume <1,5 cc. Phallus is childlike’ and stage five: ‘The genitalia are adult in size and shape. Testes volume >20 cc’.

The hair distribution for both boys and girls are in stage one ‘no hair’ and in stage five ‘adult pattern’. Tanner staging in the HELENA study has been described in a methodological paper (Iliescu et al., 2008).

3.2.2.3 Blood pressure

Blood pressure was measured with an automatic oscillometric device (OMRON M6) (Iliescu et al., 2008). The blood pressure was measured in the morning after the adolescent had first sat quietly for 5 minutes, with the back supported, feet on the floor and the right arm supported with the cubital fossa at heart level. Two recordings of systolic and diastolic measurements (in mm Hg) were made, 5 minutes apart, and the lowest value of the 2 recordings was retained (Iliescu et al., 2008).

The blood pressure was measured in duplicate during the pilot study and 189 adolescents were evaluated. The mean and standard deviation of measurements did not differ significantly between the first and the second blood pressure determination (121 ± 0.9 mmHg versus 117 ± 0.9 mmHg for systolic blood pressure and 66 ± 0.6 mmHg versus 65 ± 0.6 mmHg for diastolic blood pressure) (Iliescu et al., 2008).

3.2.2.4 Blood sample

Blood samples were drawn, by a nurse, between 8:00 and 10:00 in the morning after a 10 hour overnight fast without stasis via venipuncture of the antecubital vein. Each subject donated approximately 20 ml blood. The blood was transported to the University in Bonn and analysed within 24 hours. Serum triglycerides (TG), total cholesterol (TC), high-density lipoprotein cholesterol (HDLc), low-density lipoprotein cholesterol (LDLc) and glucose were measured on the Dimension RxL clinical chemistry system (Dade Behring, Schwalbach, Germany) with enzymatic methods following the manufacturer's reagents and instructions. During the pilot study, three blood samples with high, mean and low baseline values were tested for stability. The results showed that no changes in fresh serum samples were observed over a time span of 24 hours either at high or low baseline levels (Gonzalez-Gross et al., 2008).

Insulin concentrations were measured by a solid-phase two-site chemiluminescent immunometric assay with an Immulite 2000 analyser (DPC Biermann GmbH, Bad Nauheim, Germany) using the manufacturer's reagents and instructions. The homeostasis model assessment (HOMA) was calculated as fasting insulin (mU/l) \times fasting glucose (mg/dl)* 0.0555 divided by 22.5 (Wallace et al., 2004). A detailed description of blood sampling and procedures has been published elsewhere (Gonzalez-Gross et al., 2008).

3.2.2.5 Cardiorespiratory fitness

Cardiorespiratory fitness was assessed by means of the '20m shuttle run test' (Leger et al., 1988). Participants were required to run between two lines 20 metres apart, while keeping pace with audio signals emitted from a pre-recorded CD. The initial speed was 8.5 km/h, which was increased by 0.5 km/h each minute (1 min equals one stage). All measurements were carried out under standardised conditions in an indoor gymnasium. The participants were encouraged to keep running for as long as possible. The last completed stage or half-stage at which the participant dropped out was scored. Cardiorespiratory fitness (i.e. VO_2 max in ml/kg/min) was estimated from the last half-stage completed, sex, age, weight and height (Ruiz et al., 2008). This test has been shown to be valid (Castro-Pinero et al., 2009), reliable (Ortega et al., 2008a, Artero et al., 2011), and feasible to be used in population-based studies and in the school setting (Ruiz et al., 2006, Ortega et al., 2008b, Espana-Romero et al., 2010).

3.2.3 Socio-demographical factors

In large-scale surveys in adolescent populations it is not always possible to use registered data or to obtain information directly from the parents; in these cases reports by the adolescents are used. An early review shows that proxy reports among adolescents are most accurate if they lived at home and were reporting on the parent's current status (Looker, 1989). Vereecken & Vandeghechuchte (2003) showed that children aged 11-12 years were able to describe their parents' occupational activity in enough detail to be useful for research on socio-economic differences.

The HELENA pilot study collected socio-demographical data with self-reported questionnaires and where questions either caused problems for one or more of the participating centre's or where the question was completed by < 85 % of the adolescents, those questions were reviewed for deletion or modification (Iliescu et al., 2008).

The adapted questionnaire, used in the HELENA study, was designed to assess socio-demographic status and gathered general information about the education and occupation level of both parents, parental employment status, family structure, number of siblings, how 'well off' the family was (the adolescent's perception of the family's affluence), and family affluence scale (FAS) (Iliescu et al., 2008). Data on sex, age and centre were collected in the case report form, completed by a physician. Table 3 show the socio-demographical variables use in this thesis.

Table 3: Socio-demographic variables used in this thesis.

- **Age**
 - < 15 years
 - ≥ 15 years

 - **Region**
 - Southern (Greece, Italy and Spain)
 - Northern/central (Austria, Belgium, France, Germany, Hungary and Sweden)

 - **Education mother and Education father**
 - Low/medium education: elementary-, lower secondary-, higher secondary education
 - High education: third-level/university studies

 - **Occupation mother and Occupation father** (based on the International Standard Classification of Occupation, ISCO)
 - High - ISCO 1-2
 - Medium - ISCO 3-5
 - Low - ISCO 6-9
 - Undefined - ISCO 10-12

 - **Parents employment status**
 - Working: working full-time, working part-time,
 - Not working: housewife, retired or sick, trainee / student looking for work, pensioner, temporarily unemployed (e.g.: maternity leave)

 - **Family structure**
 - Traditional family: with both of your parents, with your mother and her partner, with your father and his partner
 - Single-parent/shared-care families: with your mother, with your father, with your mother half time and your father half time, with your grandparents or other relatives, with your foster or/adoptive parents, in an orphanage or somewhere else

 - **How well off** (Perceived family affluence) (very well off 1 to not well off 5)
 - Well off (answer 1-2)
 - Not well off (answer 3-5)

 - **FAS** (Family affluence scale): own bedroom, how many cars, how many computers and internet connections at home
 - Low FAS (≤ 3 items)
 - High FAS (≥ 4 items)
-

3.3 Statistical analysis

Table 4 show the statistical analysis included in this thesis. In all the analyses a weighting factor for age and sex was used in order to adjust for imbalances in the observed group sample sizes. Separate analyses were performed for boys and girls as breakfast habits often differ between the sexes (Rampersaud et al., 2005, Timlin et al., 2008).

The continuous data in Paper IV were checked for normality and transformed to the logarithmic scale where normality was absent. The characteristics of participants and outcomes were described as percent, mean, standard deviation (SD) and standard

error of mean (s.e. or S.E.M). The R^2 coefficient, the strength of association, was measured with Nagelkerker R^2 .

Table 4: The different statistical methods used in this thesis.

	Paper I	Paper II	Paper III	Paper IV
Bland and Altman	X			
Kappa statistics	X			
Spearman’s correlation coefficients	X			
Wilcoxon signed-rank tests	X			
Logistic regression		X	X	
Multiple linear regression		X		
Chi-square test				X
One-way ANCOVA				X
Two-way ANCOVA				X

The different statistical methods will briefly be described.

Bland-Altman is a graphical method to plot the difference of two measurements against the mean for each subject (Bland and Altman, 1986). In this thesis the total energy and nutrient were compared between two 24-h recall (self-report and interviewed).

Kappa statistics measure the agreement between methods for categorical variables, often presented as κ (Siegel and Castellan, 1988). Kappa statistics were used in this thesis for measuring the agreement between two 24-h recall (self-report and interviewed) methods in consumption versus non-consumption of the different food groups.

Spearman’s correlation coefficients is a nonparametric method, presented as (r), to quantify correlations between ranked values (Motulsky, 1995).

The Wilcoxon signed rank test is a nonparametric method to compare two paired groups. The Wilcoxon converts scores to ranks and compares them at Time 1 and at Time 2 (Motulsky, 1995).

The Wilcoxon signed rank test and Spearman’s correlation coefficients were in this thesis used to compare the total energy, nutrient and food groups between two 24-h recall (self-report and interviewed).

Logistic regression is used to test models to predict categorical outcomes with two or more categories. The results of the analyses are presented as odds ratios (OR) and confidence intervals (C.I.). OR and C.I. greater than 1 indicate that participants were more likely to engage in the outcome behaviour in comparison with the reference group (Motulsky, 1995). In this thesis multiple logistic regressions analyses were used to investigate associations of breakfast consumption (‘breakfast consumer’ versus

'breakfast skipper'), food groups for breakfast ('consumed' versus 'not consumed') and factors (individual and socio-environmental factors) influencing the choices of food at breakfast ('influence' versus 'no influence') as dependent variables. The regressions in the different papers includes some or all of this variables sex, age, region or study centre and socio-demographical factors (parental education and occupation, parents' employment status, living situation, siblings, perception of being 'well off', and the FAS score) as independent factors.

Multiple linear regressions explore the relationship between one continuous dependent variables and a number of independent variables. The results are presented as β . If X change by one unit while all other values are constant, then Y increases by β (Y decrease if β is negative) (Motulsky, 1995). Multiple linear regression analyses were, in this thesis, applied to evaluate associations between the 'breakfast index' as dependent variable and sex, age (in years, continuous), region, mother and father education level, family structure and FAS score as independent variables.

Chi-square test determines if two categorical variables are related (Motulsky, 1995).

ANCOVA – analysis of covariance - compares more than two means (Motulsky, 1995). The one-way ANCOVA was used for comparing mean levels of CVD risk factors across breakfast consumption categories (i.e. consumer, occasional consumer, and skipper) with breakfast consumption categories as the fixed factor, CVD risk factors as dependent variables, and age, centre (random variable), mother's and father's education, and family structure entered as covariates. Analyses including waist circumference were additionally adjusted for height. The two-way ANCOVA was performed to measure the interaction between breakfast consumption and weight status (i.e. non-overweight and overweight/obese) on CVD risk factors, breakfast consumption and weight status as fixed factors, adjusting for the above-mentioned covariates.

All analyses were performed using IBM SPSS statistics software for Windows version 15.0 (Paper I), version 19 (Paper II and III), version 16 (Paper IV), and the level of significance was set at 5 %.

4 RESULTS

4.1 Population characteristics

The final number of subjects included in the HELENA Study was 3528 adolescents.

Age and sex distribution in the different Papers are shown in Figure 4 and Table 4.

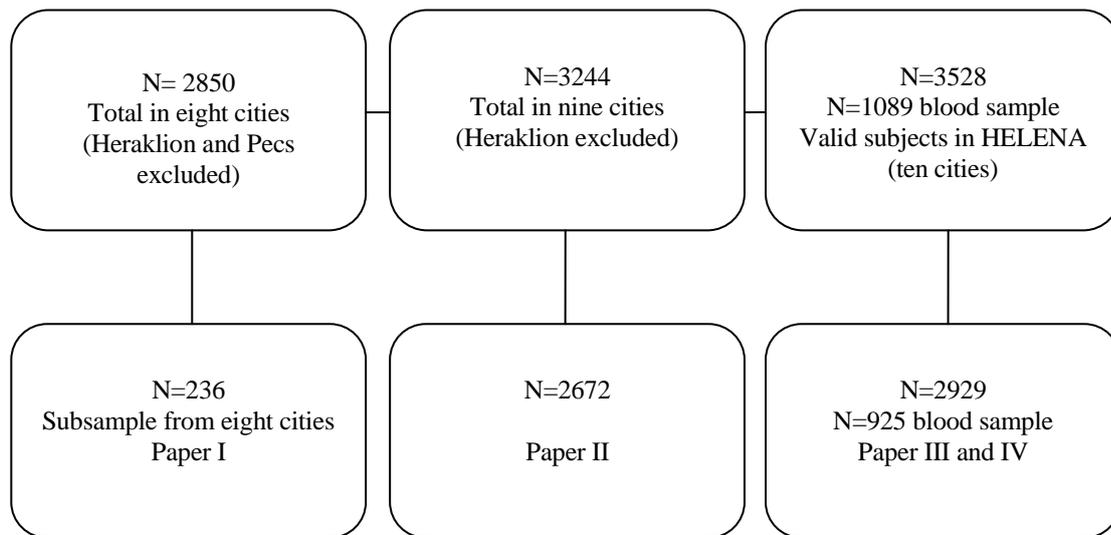


Figure 4: Population in the different papers

Table 4 Age and sex distribution in the HELENA study and in the different papers included in this Thesis

	N (% of total)	Sex % Girls	Age Mean (sd)
Total			
In 10 cities (III, IV)	3528	52	14.7 (1.2)
Blood sample (10 cities) (IV)	1089	53	14.7 (1.2)
In 9 cities (II)	3244	52	14.8 (1.2)
In 8 cities (I)	2850	53	14.8 (1.2)
Paper IV			
Total	2929 (83%)	53	14.7 (1.2)
Blood sample	925 (83%)	53	14.7 (1.2)
Paper III	2929 (83%)	53	14.7 (1.2)
Paper II	2672 (82%)	53	14.8 (1.2)
Paper I (sub-sample from 8 cities)	236 (8%)	51	14.6 (1.7)

The roman numerals in the paragraph refer to the different papers

4.2 Evaluation of 24-h recall (YANA-C) (Paper I)

Figure 5 shows the Spearman's correlation coefficients and kappa statistics for the two 24-h recalls (self-administered and interview). The kappa statistics shows that the food group intake showed good agreement between the methods in 'consumption' versus 'non-consumption'; 0.73 or higher on all food items. Spearman's correlation coefficients between the two methods were high for all food groups, for the total sample (≥ 0.76) as well as for the consumers only (≥ 0.68). More food items were reported in the interview compared to the self-report, and it was mostly items that are considered 'easy to forget' like 'sauce', 'sugar, jam and syrup', 'chocolate' and 'fat'. The proportion of food items reported in the self-report but not in the interview was very low.

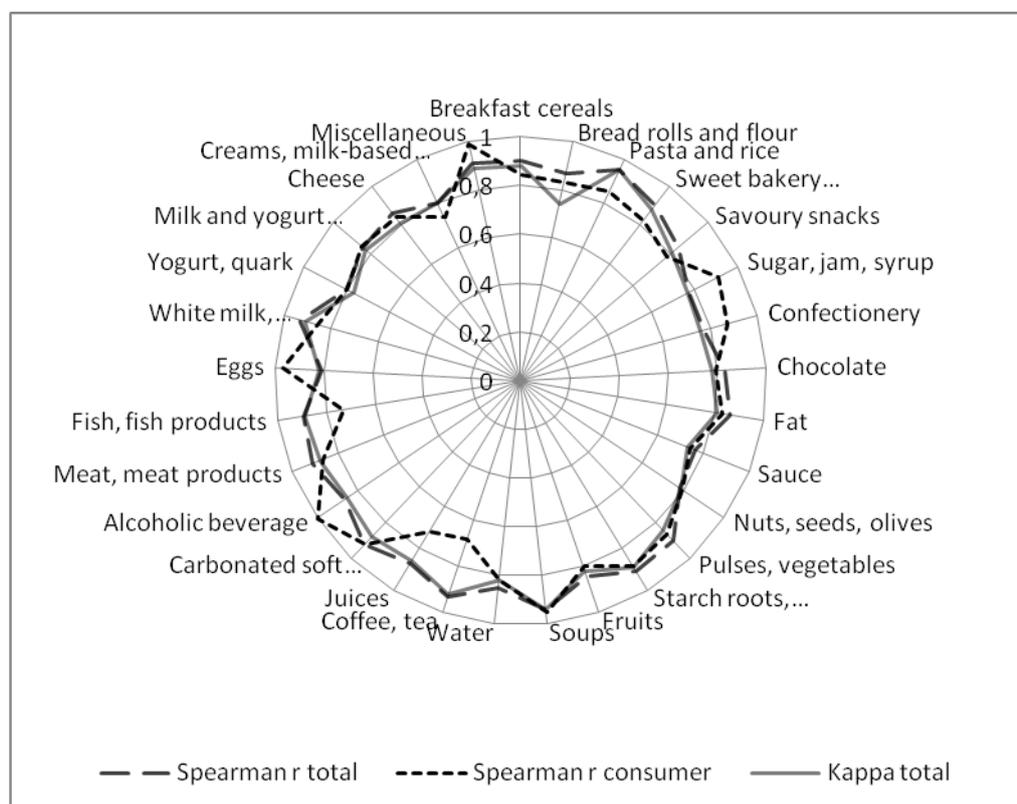


Figure 5: The correlation, measured with Spearman's correlation coefficients (r) and kappa, between the two 24-h recalls (self-administered and interview). The agreement between the methods is measured in the total sample (Spearman and kappa) and for consumers only (Spearman).

Energy and fat intakes were significantly underestimated in the self-report compared to the interview, as measured with the Wilcoxon signed-rank test. All other nutrients (protein, carbohydrates, fibre, calcium, iron and ascorbic acid) were not

significantly different between the two methods. Spearman’s correlation coefficients were high for all included nutrients ranging between 0.86 and 0.91.

4.3 Breakfast consumption and their association to socio-demographical factors (Paper II and III)

Figure 6 shows that breakfast consumption on both recall days, when measured with the 24-h recall, was reported among 77 % of the adolescents, and 7 % of the adolescents were ‘breakfast skippers’. To the statement ‘I often skip breakfast’ 37 % strongly disagreed (breakfast consumer) and 17 % strongly agreed (breakfast skipper).

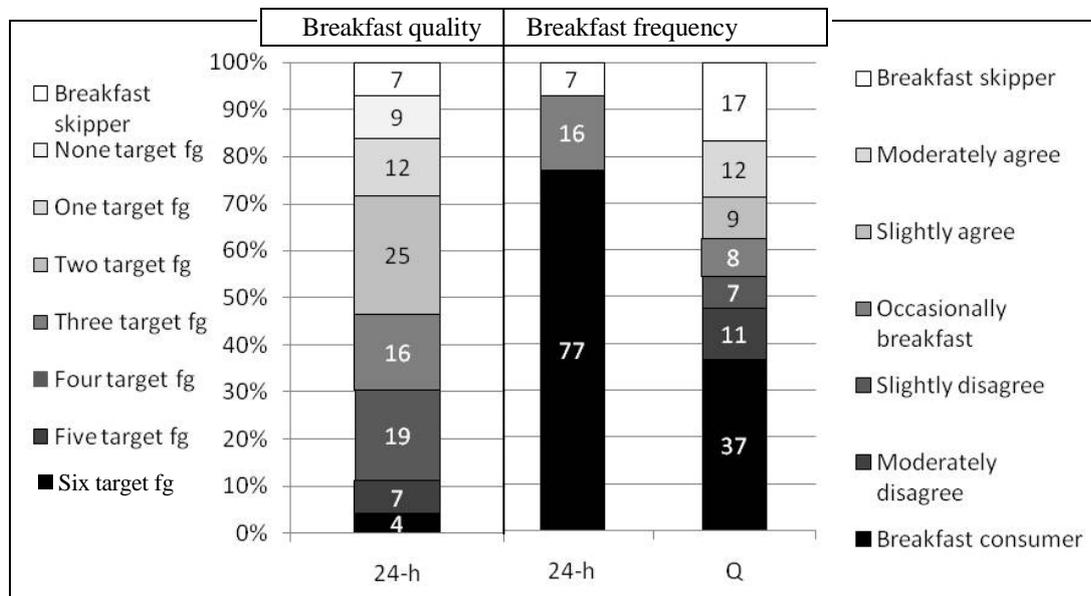


Figure 6: Percent of breakfast quality from the 24-h recall (left part of the figure) and breakfast frequency (consumer vs skipper) from both 24-h recalls and from the response to the statement ‘I often skip breakfast’ (right part of the figure).

Q = questionnaire

24-h = 24-h recall

Fg = food group

Table 5: Results of multivariate logistic regression analyses with breakfast consumption (both questionnaire and 24-h recall) as dependent variable and socio-demographic factors as independent variables: (OR 95% C.I.) weighted for age and sex.

	Questionnaires ^a						24-h recall ^b		
	Boys (n=829)			Girls (n=1006)			n=2223		
	OR	95% CI	P ^d	OR	95% CI	P ^d	OR	95% CI	P ^d
Sex (boys ^c)									
Girls							1.09	0.78-1.53	0.613
Age (\geq 15 years ^c)									
< 15 years	1.35	0.99-1.83	0.053	1.06	0.82-1.39	0.642	1.66	1.17-2.35	0.005
Education of mother (high ^c)									
Low/medium	0.72	0.48-1.08	0.110	0.52	0.37-0.74	<0.001	0.61	0.38-0.98	0.040
Education of father (high ^c)									
Low/medium	0.76	0.51-1.14	0.185	0.86	0.60-1.22	0.396	0.80	0.51-1.27	0.351
Family structure (traditional ^c)									
Shared-care	0.55	0.38-0.81	0.003	1.00	0.69-1.46	0.978	1.04	0.67-1.60	0.874
FAS (internet, pc, cars, own room) (\geq 4 items ^c)									
\leq 3 items	0.90	0.60-1.36	0.630	0.70	0.50-0.98	0.036	0.73	0.49-1.08	0.118
Nagelkerke	0.107			0.079			0.029		

^a The regression model also included centre, occupation of father and mother, parents' employment status, the adolescent's perception of the family's affluence, number of siblings, parent and peers behaviour and parent and peers encouragement.

^b The regression model also included centre.

^c Reference value.

^d Bold type p < 0.05

Table 5 shows that younger adolescents (< 15 years of age) were more likely to report that they were 'breakfast consumers' in comparison to older adolescents, when measuring breakfast consumption with 24-h recall. No age differences were seen when measuring breakfast consumption with the statement 'I often skip breakfast'.

Fewer adolescents with a mother with a low/medium education level indicated that they were 'breakfast consumers' compared to adolescents with a mother with a high education level, when measured with the 24-h recall. When measuring breakfast consumption with the statement 'I often skip breakfast' girls whose mothers had a low/medium education level were less likely to be regular breakfast consumers compared to girls with mothers with a high education level.

There were no significant differences in breakfast consumption ('consumer' versus 'skipper') by sex, region, fathers' education, family structure and FAS when measuring breakfast consumption with 24-h recall.

When measuring breakfast with the statement 'I often skip breakfast', fewer girls indicated that they were breakfast consumers compared to boys (OR, 0.77; 95% CI, 0.64-0.94, p < 0.05). Boys who perceived that the family was 'not well off' were more likely to be regular breakfast consumers (OR, 1.55, 95% CI, 1.13-2.13, p < 0.01) compared to boys who perceived that the family was 'well off'.

Table 5 shows that boys from single-parent/shared-care families were less likely to be regular breakfast consumers compared to boys from traditional families. Girls who had a low FAS score were less likely to be regular breakfast consumers compared to their counterparts with high FAS scores. The remaining socio-demographical factors (centre, father's education, parental occupation, parents' employment status and siblings) did not differ significantly in either boys or girls between the breakfast consumption groups when measuring breakfast with the statement 'I often skip breakfast'.

Boys whose parents gave little or no encouragement to eat a healthy diet were less likely to be regular breakfast consumers (OR, 0.59, 95% CI, 0.43-0.81, $p < 0.01$) compared to boys whose parents often gave encouragement to eat a healthy diet. Girls whose peers ate unhealthily were less likely to be regular breakfast consumers (OR, 0.69, 95% CI, 0.52-0.91, $p < 0.01$) compared to those whose peers ate healthily. Boys whose parents ate unhealthily were less likely to be regular breakfast consumers (OR, 0.70, 95% CI, 0.50-0.96, $p < 0.05$) compared to those whose parents ate healthily. Boys whose peers gave little or no encouragement to eat a healthy diet were more likely to be regular breakfast consumers (OR, 1.44, 95% CI, 1.04-2.00, $p < 0.05$) compared to adolescents whose peers often gave encouragement to eat a healthy diet.

The variation explained in the regression (when measuring breakfast with the statement 'I often skip breakfast') was 0.11 for boys, 0.08 for girls and when measuring breakfast with the 24-h recall the variation was 0.03, estimated with Nagelkerker R^2 (Table 5).

4.4 Breakfast quality and its association with socio-demographical factors (Paper II)

Our study showed that 4 % of adolescents consumed three of the target food groups for breakfast, on both recall days (Figure 6, see section 4.3). Figure 6 shows also that 53 % of the adolescents consumed products from two or fewer of the target food group and 30 % consumed four or more of the target food groups on both recall days.

Breakfast quality was higher in adolescents from the northern and central part of Europe ($\beta = 0.142$, $p < 0.001$), in those who had a mother with a high education level ($\beta = 0.129$, $p < 0.001$), reporting higher FAS ($\beta = 0.068$, $p = 0.002$) and those coming from traditional families ($\beta = 0.068$, $p = 0.002$). Breakfast quality was lower among

older adolescents in comparison to younger ($\beta = -0.063$, $p = 0.001$). There was no association between breakfast quality and sex or father's education.

Girls were more likely to drink 'tea and coffee' and to eat 'butter' (both $p < 0.05$) for breakfast than boys. Girls were also less likely to eat 'meat, fish and eggs' ($p < 0.05$) for breakfast compared to boys. Younger adolescents (< 15 years of age) were more likely to drink 'other milk products' ($p < 0.001$) and less likely to drink/eat 'tea and coffee', 'water' and 'added sugar' (all $p < 0.05$) in comparison to older adolescents. Adolescents from northern/central parts of Europe were more likely to have a drink (tea, coffee, fruit juice and soft drink) ($p < 0.001$ for all) for breakfast compared to those from the southern part of Europe. They were also more likely to eat 'cheese', 'other milk products', 'meat, fish and eggs', 'fruit and vegetables', 'bread', 'cereals' and 'added fat or oil' (all $p < 0.001$) compared to their counterparts from southern Europe. Adolescents from northern/central Europe were less likely to drink/eat 'milk and yoghurt', 'cakes', 'sweets' and 'added sugar' (all $p < 0.001$) for breakfast compared to those from southern Europe.

Adolescents whose mothers have a low/medium education level were less likely to drink 'fruit juice' and 'milk and yoghurt' (both $p < 0.001$) and to eat 'fruit and vegetables' and 'bread' (both $p < 0.05$) for breakfast compared to those whose mothers have a high education level. The adolescents whose mothers have a low/medium education were also more likely to drink 'soft drinks' ($p < 0.001$) for breakfast in comparison to those whose mothers have a high education level. Adolescents from single-parents/shared-care families were less likely to eat 'sweets' ($p < 0.01$) for breakfast compared to those from traditional families. Adolescents who reported lower FAS were less likely to drink 'fruit juice' and 'milk and yoghurt' (both $p < 0.01$) and to eat 'cereals', 'sweets' and 'added sugar' (all $p < 0.001$) for breakfast compared to those with high FAS. Low FAS adolescents were also more likely to drink/eat 'other milk products' ($p < 0.01$), 'meat, fish and eggs' and 'vegetable fat' (both $p < 0.001$) for breakfast in comparison to those who reported high FAS. There were no significant differences in food groups for breakfast by level of father's education.

4.5 Factors influencing the adolescents food choices for breakfast and their association with socio-demographical factors (Paper III)

The personal factors ‘hunger’, ‘taste of the food’ and ‘concern for health’ and the socio-environmental factor ‘parents or guardian’ were the most important influences on adolescents’ food choices at breakfast. Between 44 %-59 % of respondents believed these factors to have a strong or very strong influence. The factor ‘price of the food’, ‘the school environment’ and ‘friends’ had much less influence, between 11 %-14 % reported that these factors had a strong or very strong influence (Figure 7). The pattern was similar for boys and girls (data not shown).

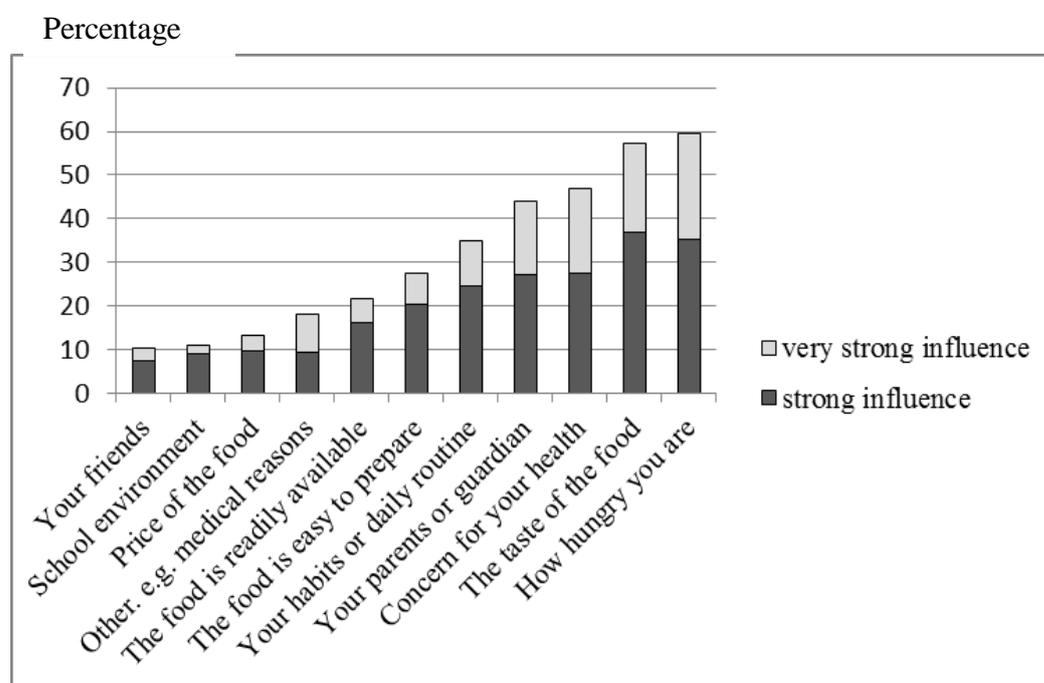


Figure 7: Factors influencing adolescents’ choice of foods to breakfast.

4.5.1 Personal factors

The factors ‘concern for health’ (OR, 2.14, 95% CI, 1.61-2.83, $p < 0.001$) and ‘daily routine’ (OR, 1.67, 95% CI, 1.30-2.15, $p < 0.001$) influenced the girls more than the boys in their choice of food for breakfast. Adolescents younger than 15 years of age were more influenced by ‘medical reasons’ (OR, 1.38, 95% CI, 1.05-1.81, $p < 0.05$) and less influenced by ‘ease of preparation’ (0.78, 95% CI, 0.61-1.00, $p < 0.05$) in comparison to the older adolescents in their choice of food for breakfast. Adolescents from southern Europe were more influenced by ‘concern for health’ (OR, 2.26, 95%

CI, 1.60-3.19, $p < 0.001$), ‘medical reasons’ (OR, 1.80, 95% CI, 1.33-2.42, $p < 0.001$) and less influenced by ‘hunger’ (OR, 0.61, 95% CI, 0.43-0.86, $p < 0.01$) and ‘ease of preparation’ (OR, 0.76, 95% CI, 0.58-1.00, $p < 0.05$) in their choices of food for breakfast compared to adolescents from the northern and central part of Europe. For those adolescents whose mothers had a low/medium education level, the factor ‘concern for health’ (OR, 1.51, 95% CI, 1.05-2.16, $p < 0.05$) and ‘daily routine’ (OR, 1.40, 95% CI, 1.00-1.95, $p < 0.05$) had a larger influence on food choices at breakfast compared to those whose mothers had a high education level. Among those adolescents whose fathers had a high education level, the ‘daily routine’ (OR, 0.61, 95% CI, 0.44-0.86, $p < 0.01$) had a larger influence on food choices at breakfast compared to those whose fathers had a low/medium education level. There were no socio-demographic differences seen for the personal factor ‘taste of the food’. The variation explained in the regressions varied between 0.03-0.10 estimated with Nagelkerker R^2 .

4.5.2 Socio-environmental factors

Girls were more influenced by their ‘parents or guardian’ (OR, 1.36, 95% CI, 1.05-1.77, $p < 0.05$) and less influenced by whether ‘the food is readily available’ (OR, 0.78, 95% CI, 0.62-1.00, $p < 0.05$) in their choices of food for breakfast compared to boys. Adolescents younger than 15 years of age were more influenced by ‘parents and guardians’ (OR, 1.54, 95% CI, 1.18-2.01, $p < 0.01$) in comparison to the older adolescents in their choice of food for breakfast. Adolescents from southern Europe were more influenced by ‘parents or guardian’ (OR, 2.59, 95% CI, 1.88-3.59, $p < 0.001$) ‘school environment’ (OR, 1.88, 95% CI, 1.42-2.50, $p < 0.001$) and ‘friends’ (OR, 1.51, 95% CI, 1.12-2.02, $p < 0.01$) and less influenced by whether ‘the food is readily available’ (OR, 0.66, 95% CI, 0.50-0.87, $p < 0.01$) in their choices of food for breakfast compared to adolescents from the northern and central part of Europe. For those adolescents whose mothers had a low/medium education level, ‘price of the food’ (OR, 1.75, 95% CI, 1.26-2.43, $p < 0.01$) had a larger influence on food choices at breakfast compared to those whose mothers had a high education level. For those adolescents whose fathers had a low/medium education level, the ‘parents or guardian’ (OR, 0.48, 95% CI, 0.48-0.99, $p < 0.05$) had less influence on food choices at breakfast compared to those whose fathers had a high education level. Finally, adolescents who perceived themselves as being ‘not well off’ were less influenced by the ‘school environment’ (OR, 0.75, 95% CI, 0.58-0.97, $p < 0.05$) and ‘friends’ (OR, 0.64, 95% CI,

0.49-0.84, $p < 0.01$) in comparison to those who perceived themselves as being ‘well off’ in their choices of food for breakfast. There were no significant differences for the socio-demographical variables ‘parents’ employment status’, ‘family structure’ and ‘FAS’ for any of the personal and socio-environmental factors. The variation explained in the regressions varied between 0.04-0.09 estimated with Nagelkerker R^2 .

4.6 Breakfast consumption and its association with cardiovascular disease risk factors (Paper IV)

Among boys, breakfast consumers had a significantly lower BMI, sum of skinfold thickness, waist circumference, systolic and diastolic blood pressure (all $p < 0.001$), as well as lower TC/HDLc, LDLc/HDLc, glucose, insulin and HOMA (all $p < 0.01$) and lower LDLc ($p < 0.05$) compared to the skipper group. No association was observed between breakfast and TG, TC, or HDLc. The variation explained varied between 0.01-0.13. Among girls, breakfast consumers had a lower sum skinfold thickness ($p < 0.01$) BMI, insulin and HOMA (all $p < 0.05$), whereas no association was observed between breakfast and the other studied CVD risk factors. The variation explained varied between 0.001-0.10. Both boys and girls who reported to consuming breakfast regularly had higher levels of cardiorespiratory fitness (both $p < 0.001$) compared to the skipper group.

Among boys, there was a breakfast consumption*weight status interaction effect for TC and LDLc. Boys who were breakfast consumers and overweight/obese had lower TC and LDLc compared to the skipper group. Among girls, there was an interaction effect between breakfast consumption*weight status for glucose (Table 6). These results persisted after excluding underweight adolescents from the analysis and when the analyses were additionally adjusted for pubertal status (data not shown).

Table 6: Cardiovascular risk factors by breakfast consumption categories, sex, and weight status in European adolescents.

	Boys						Girls							
	Non-overweight (n=1007)		Overweight/obese (n=363)		P [†]	P [‡]	P [§]	Non-overweight (n=1243)		Overweight/obese (n=316)		P [†]	P [‡]	P [§]
	mean	SEM	mean	SEM				mean	SEM	mean	SEM			
VO _{2max} (ml/kg/min)*														
consumer	54.6	0.3	43.6	0.7				37.7	0.3	32.3	0.7			
occasional	53.0	0.5	41.5	0.9	***	**		36.5	0.4	33.6	0.8	***	**	
skipper	51.8	0.6	41.7	0.8				35.4	0.4	31.6	0.7			
Sys BP (mmHg)														
consumer	122	0.6	131	1.1				115	0.5	122	1.1			
occasional	122	0.9	130	1.4	***	***		115	0.7	123	1.4	***		
Skipper	125	0.9	136	1.3				115	0.6	122	1.1			
Dias BP (mmHg)														
consumer	66	0.4	69	0.8				68	0.4	72	0.9			
occasional	66	0.6	70	1.0	***	***		67	0.6	73	1.1	***		
skipper	69	0.6	72	0.8				68	0.5	72	0.9			
Blood parameters	n=322		n=111					n=396		n=96				
TG (mg/dL)*														
consumer	60.5	2.4	76.5	4.4				71.4	3.1	99.2	7.0			
occasional	59.2	4.3	74.2	8.6	***			70.9	4.5	75.1	10.1	**		
skipper	65.3	3.9	79.8	5.0				68.2	3.6	80.0	6.4			
TC (mg/dL)														
consumer	153.9	2.0	147.9	3.8				168.3	2.3	168.1	5.2			
occasional	151.5	3.6	165.3	7.4		*	*	165.7	3.3	170.9	7.5			
skipper	154.5	3.3	164.0	4.3				166.9	2.7	171.0	4.7			
HDLc (mg/dL)														
consumer	55.5	0.7	47.9	1.4				59.1	0.9	52.0	2.0			
occasional	54.7	1.3	50.8	2.7	***			57.6	1.3	55.2	2.8	**		
skipper	53.3	1.2	47.5	1.6				58.2	1.0	53.9	1.8			
LDLc (mg/dL)														
consumer	88.3	1.8	90.0	3.5				97.1	2.0	101.6	4.5			
occasional	85.9	3.4	102.7	6.8	**	**	*	95.6	2.9	103.3	6.6			
skipper	90.6	3.1	106.2	4.0				96.5	2.4	103.5	4.2			
TC/HDLc*														
consumer	2.85	0.05	3.14	0.10				2.89	0.05	3.31	0.11			
occasional	2.83	0.10	3.36	0.19	***	*		2.94	0.07	3.21	0.16	***		
skipper	3.00	0.09	3.49	0.11				2.95	0.06	3.27	0.10			
LDLc/HDLc														
consumer	1.66	0.05	1.92	0.09				1.68	0.04	2.01	0.10			
occasional	1.63	0.09	2.12	0.18	***	*		1.72	0.06	1.99	0.15	***		
skipper	1.79	0.08	2.27	0.11				1.73	0.05	1.99	0.09			
Insulin (µU/mL)														
consumer	7.4	0.4	11.5	0.8				8.6	0.4	12.9	0.8			
occasional	10.7	0.8	12.5	1.6	***	*		9.1	0.5	9.6	1.2	***	*	
skipper	9.5	0.7	12.5	1.0				9.9	0.4	13.1	0.8			
Glucose (mg/dL)														
consumer	91.3	0.5	92.7	1.1				88.2	0.5	88.5	1.1			
occasional	92.0	1.0	93.1	2.1		*		89.8	0.7	85.5	1.6		*	**
skipper	94.3	0.9	95.1	1.2				88.9	0.6	91.6	1.0			
HOMA*														
consumer	1.7	0.1	2.7	0.2				1.9	0.1	2.8	0.2			
occasional	2.4	0.2	2.8	0.4	***			2.0	0.1	2.0	0.3	***		
skipper	2.3	0.2	3.0	0.2				2.2	0.1	3.0	0.2			

Values are means and standard error of the mean (SEM).

* Analysis was performed on log-transformed data, but non-transformed data are presented as mean and SEM

† Main effect of weight status by two-way analysis of covariance (ANCOVA).

‡ Main effect of breakfast consumption by two-way ANCOVA.

§ Interaction effect between breakfast consumption and weight status by two-way ANCOVA.

All analyses were adjusted for centre (random variable), age, mother's education, father's education and family structure.

BP indicates blood pressure; HDLc, high density lipoprotein cholesterol; HOMA, homeostasis model assessment; LDLc, low density lipoprotein cholesterol; TG, triglycerides; TC, total cholesterol; VO_{2max}, maximum oxygen consumption.

*** p < 0.001, **p < 0.01, *p < 0.05

5 DISCUSSION

5.1 Evaluation of the 24-h recall

The self-administered 24-h recall was developed for adolescents and to be used with minimal professional assistance. The advantages of a self-administered computer tool are that the questions are standardised and presented in the same order, pictures of food items are easy to incorporate (Vereecken et al., 2010) and a result can be presented immediately after finishing the program. The disadvantages include the need for computer literacy, lack of nutritional knowledge to understand the way the food are categorised as well as potential bias in the responses if an interviewer is required (Probst and Tapsell, 2005).

In this thesis a comparison was made between a computerised self-administered 24-h recall and a computerised interview-administrated 24-h recall. In general both administration modes agreed very well, for energy, nutrients and food groups. Burrows et al. showed in a review under-reporting is common in dietary studies when dietary assessment is validate against doubly labelled water among adolescents (Burrows et al., 2010). Even if the evaluation shows good agreement between the two methods the validity could be low. Our study showed low energy intake for some of the centres and that could indicate under-reporting.

Although no instrument can meet all needs, future assessment tools will need to come closer to the ideal to be useful not only to researchers but also to clinicians who need to identify nutritional problems and initiate counselling.

5.2 Breakfast habits among adolescents

Daily breakfast consumption differs, and varies in the HBSC study (among the countries included in HELENA), from 33 % (Greek girls) to 73 % (Swedish boys) (Vereecken 2009). Our results, from the 24-h recall, that three-quarters are breakfast consumers, are in agreement with Swedish boys daily breakfast consumption frequency in the HBSC. Rampersaud showed that breakfast skipping range among adolescents in the United States and Europe, from 10 % to 30 % (Rampersaud 2005), which is similar to our results.

In our study a majority of the adolescents (96 %) did not consume a breakfast including products from all three target food groups on both of the two recall days. Additionally, half of the adolescents consumed products from no more than two of the

target food groups during the two recall days. Similar results have been reported among different subpopulations in Europe (Raaijmakers et al., 2010, Aranceta et al., 2001). Our result that only 4 % have a 'high-quality' breakfast points out the need to promote 'high-quality' breakfast habits among the adolescent group.

5.2.1 Factors influencing the adolescents' food choices for breakfast

Our results concerning factors influencing choices of food for breakfast are in accordance with the principles described in the social cognitive theory (Baranowski et al., 1999, Ball et al., 2009); (Story et al., 2008). The social cognitive theory takes into consideration the interplay between socio-environmental (social encouragement and modelling) and individual (personal and behavioural) factors. In addition to knowledge regarding healthy food habits we need to understand how their surroundings influence the adolescents in their choice of food (Trew et al., 2006). Our study shows that the personal factors ('hunger', 'taste of the food' 'concern for health') and the socio-environmental factor ('parents or guardian') were the most important influences on the adolescents' choice of food at breakfast. Fitzgerald et al have found, among Irish adolescents, that food preferences appear to be the central motivation for food choices (Fitzgerald et al., 2010). Similar findings have been shown in studies from the USA (Neumark-Sztainer et al., 1999, Story et al., 2002) and from Sweden (Berg et al., 2003). Regular 'breakfast consumption' among girls was associated with the socio-environmental factor 'peers' behaviour' and for boys there was a positive association between breakfast and parents' behaviour. Adolescent breakfast consumption has been reported, in Finland, to be associated with parental breakfast consumption (Keski-Rahkonen et al., 2003) and with frequency of family meals in North America (Utter et al., 2008, Videon and Manning, 2003). Keski-Rahkonen suggested that the best way to influence adolescents' breakfast habits is to create a family and peer atmosphere that endorses general health-conscious behaviour (Keski-Rahkonen et al., 2003).

Boys, in our study, were more likely to be regular breakfast consumers if they received encouragement from their parents to eat healthily. No such association was seen in girls. Boutelle et al. showed that adolescents' perception of their mothers' attitudes is associated with their own behaviour and attitudes (Boutelle et al., 2007). Our results together with the literature highlight the importance of adolescents' perceptions of their parents and the impact of these perceptions on adolescent attitudes and behaviour. Boys reported consuming breakfast less often when peers encouraged

them to eat healthily. This was in contrast to the influence of peers on younger children's food preferences (Taylor et al., 2005). Story et al. has raised the question that adolescents are seeking autonomy and may not believe that their behaviour is influenced by others and if they are influenced by peers it may be indirect rather than direct (Story et al., 2002).

School breakfast programs are considered to be useful (Aranceta et al., 2001, Gassin, 2001), but opinions differ regarding efficiency (Belderson et al., 2003). Studies have indicated the family to be a good arena for breakfast programs (Keski-Rahkonen et al., 2003, Matthys et al., 2007), but very few studies involving families have been done with adolescents (Mihás et al., 2009, Neumark-Sztainer et al., 2008).

5.3 Breakfast habits and their association with socio-demographical factors

5.3.1 Sex

No sex differences were reported in our study either in 'breakfast consumption' or in 'breakfast quality' when measured by 24-h recall, but boys were more likely to be regular breakfast consumers compared to girls when breakfast consumption was measured with the statement 'I often skip breakfast'. Previous studies have shown that sex differences in breakfast consumption are common (Rampersaud et al., 2005, Vereecken et al., 2009b). Sex differences have been reported among a few food groups consumed for breakfast in our study. Raaijmakers et al. have shown similar sex differences among food groups consumed for breakfast among Dutch adolescents (Raaijmakers et al., 2010). The HBSC study has reported, in nearly all countries, that girls more often choose fruit and vegetables and less often choose soft drinks compared to boys (Vereecken et al., 2005b). In our study girls reported that they were more influenced in their choices of food for breakfast by their 'parents', by 'concern for health' and their 'daily routine' compared to boys. Adolescents, especially girls, have in previously studies shown that they are concerned about their weight and shape rather than their health (Trew et al., 2006). Dieting is common among girls (Strauss, 1999) and dieting has been associated with adolescent girls' perception of being 'good for their health' (Roberts et al., 2001) and eating healthily (Neumark-Sztainer and Story, 1998). Healthy eating and dieting explained half of the sex differences in dietary behaviours and Wardle et al. concluded that girls make more healthy food choices, compared to boys (Wardle et al., 2004).

5.3.2 Age

Adolescents, in our study, younger than fifteen years old were more likely to be 'breakfast consumers' in comparison to older adolescents when breakfast consumption was measured by 24-h recall. However, we did not observe any age differences in 'breakfast consumption', when the analyses were conducted separately for boys and girls. Previous studies have shown that older adolescents skip breakfast more often than their younger counterparts (Rampersaud et al., 2005, Vereecken et al., 2009b, Raaijmakers et al., 2010). Younger adolescents, in our study, scored more highly on 'breakfast quality' in comparison to older adolescents. Aranceta reported similar results (Aranceta et al., 2001). Younger adolescents, in our study, were also more likely to drink 'other milk products' and less likely to drink/eat 'tea and coffee', 'water', 'added sugar' in comparison to older adolescents. Raaijmakers et al. have shown that consumption from the 'liquid group' (water, tea and coffee) was more common among older adolescents (Raaijmakers et al., 2010). Younger adolescents reported, in our study, that they were more influenced by their 'parents or guardian' in their choices of food for breakfast compared to older adolescents. This could reflect the adolescent's increasing autonomy with age, and indeed older adolescents reported consuming more food outside the home compared to younger adolescents (Story et al., 2002).

5.3.3 Regions of Europe

There were no significant difference in 'breakfast consumption' versus 'breakfast skipping' between the two regions of Europe (southern vs northern/central) in our study. Vereecken et al. have shown differences among countries in Europe, in the southern region daily breakfast consumption ranges from 33 % (Greek girls) to 72 % (Spanish boys) when looking at the countries included in the HELENA study. In the northern/central region daily breakfast consumption ranges from 42 % (Hungarian girls) to 73 % (Swedish boys) (Vereecken et al., 2009b). These country differences could be the reason why no discrepancy was found in breakfast consumption between the two regions. Our study shows differences in quality was seen; adolescents from northern and central parts of Europe were more likely to score a higher value on the 'breakfast quality' index than adolescents from the southern part of Europe and intake of food groups also differs between the regions. However, looking at the factors influencing food choices for breakfast, our study shows that significant differences

were found between the two regions for many factors. It is likely that the socio-cultural norms are different between southern Europe and the northern/central part. To the best of my knowledge, there are no studies investigating differences in food choices in adolescents from southern and northern/central Europe. Further research is needed on a regional or national level to better understand the determinants of food choices in adolescents living in different parts of Europe.

5.3.4 Parents' education and occupation

Our results showed that adolescents whose mothers had a high education level were more likely to be 'breakfast consumers' compared to adolescents with mothers with a low/medium education level. In the analyses that were conducted separately for boys and girls, an association was seen between breakfast consumption and mothers with high education only among girls. Mother's education levels and its association with breakfast consumption have been found both in Europe (Lien, 2007, Pearson et al., 2009b) and in the United States (Franko et al., 2008, Timlin et al., 2008).

Regarding breakfast quality, our study shows that adolescents with a mother with a high education level were more likely to have a higher value on the 'breakfast quality' index. Those adolescents were also more likely to drink and eat from the 'target food groups' and less likely to drink 'soft drinks' for breakfast. A similar pattern has been shown in Norway (Nilsen et al., 2010).

Mother's and father's occupation level as indicators for socio-demographic status did not differ between 'breakfast consumers' and 'breakfast skippers' in our study. This is in contrast to the literature, which has shown that having parents with a high-level occupation was associated with regular breakfast consumption (Sjöberg et al., 2003, Keski-Rahkonen et al., 2003). Furthermore we showed that adolescents with a mother with a high education level were less influenced by 'concern for their health', 'the daily routine' and 'the price of food' in their choices of food for breakfast, compared to adolescents with a mother with low/medium education level. Mothers have a strong influence on the family's dietary habits and influence the family food environment and the well-educated may be more likely to consider health in their choice of food (Hanson and Chen, 2007, Pearson et al., 2009a). Boutelle has shown that mother's concern for healthful eating is associated with the home food environment (Boutelle et al., 2007). A study by Vereecken et al. found that mothers of preschool children had a lower

health-attitude score if they had a low-level occupation and education (Vereecken et al., 2009b).

5.3.5 Family structure

Our results showed that adolescents living in traditional families were more likely to be ‘breakfast consumers’ compared to adolescents who lived in single-parent/shared-care families. In the analyses, that we conducted separately for boys and girls, an association was seen between breakfast consumption and family structure among boys. Boys who lived in traditional families were more likely to be ‘breakfast consumers’ than boys who lived in single-parent/shared-care families. Adolescents from traditional families were more likely to have a higher value on the ‘breakfast quality’ index and were also more likely to eat ‘sweets’ for breakfast compared to those from single-parents/shared-care families. Factors influencing food choices did not differ by family structure. An association between breakfast consumption and living in traditional families has been seen in the HBSC study, among the countries included in HELENA, except for Greece (Vereecken et al., 2009b). Family cohesiveness was associated with breakfast consumption and decreased soda intake among girls in the US (Franko et al., 2008). Explanations for our result that ‘breakfast consumption’ and ‘breakfast quality’ are higher in traditional families, could be that traditional families have adolescents who comply with parental communication about the importance of breakfast and may be more likely to consume breakfast together. With two parent’s family the opportunity is in a greater degree, that one parent will be home to consume breakfast together with the adolescents.

5.3.6 Family affluence

Boys, in our study, were more likely to be ‘breakfast consumers’ if they perceived themselves as being ‘well off’, and for girls a positive association was found between regular ‘breakfast consumption’ and FAS. Furthermore adolescents who reported high FAS were more likely to have a higher value on the ‘breakfast quality’ index and were more likely to drink/eat from the ‘target food groups’ ‘sweets’ and ‘added sugar’ and less likely to drink/eat ‘other milk products’, ‘meat, fish and eggs’ and ‘vegetable fat’ for breakfast in comparison to those who reported three items or less on the FAS. Our study also showed that adolescents who perceived themselves to be ‘well off’ reported that they were more influenced by the ‘school environment’ and ‘friends’ in their

choices of food for breakfast compared to those who perceived themselves to be ‘not well off’. The HBSC study showed an association between high FAS and ‘breakfast consumption’ in five of the countries included in HELENA (Belgium, France, Germany, Hungary and Sweden) (Vereecken et al., 2009b). A study in Wales showed that among children (9-11 years), being from socio-economically deprived families appeared to be associated with a lower consumption of fruits and cereals and increased consumption of sweets and crisps for breakfast (Moore et al., 2007).

5.4 Breakfast consumption and its association with cardiovascular disease risk factors

Adolescents who are regular ‘breakfast consumers’, in our study, had a lower body fat content. The results also showed that regular ‘breakfast consumption’ is associated with higher cardiorespiratory fitness in both boys and girls, and with a healthier cardiovascular profile, especially in boys. Interestingly, consuming breakfast regularly may attenuate the effect of excess adiposity on TC and LDLc in boys.

Previously studies support our results that breakfast consumption is associated with lower body fat content (Rampersaud et al., 2005, Szajewska and Ruszczynski, 2010). Two reasons for this association seems to be important; daily ‘breakfast consumers’ are likely to be more physical active (Keski-Rahkonen et al., 2003) and more likely to have a higher ‘dietary quality’ (Giovannini et al., 2008, Matthys et al., 2007, Barton et al., 2005) than ‘breakfast skippers’. Mean waist circumference (a surrogate measure of abdominal adiposity) was lower among boys who were ‘breakfast consumers’, which concurs with a previous study (Deshmukh-Taskar et al., 2010).

‘Breakfast consumption’, in our study, was associated with higher cardiorespiratory fitness in both boys and girls. Similar results have previously been reported (Sandercock et al., 2010). As mentioned above, ‘breakfast consumers’ seem to have a more active lifestyle compared to breakfast skippers (Keski-Rahkonen et al., 2003, Corder et al., 2010). This clustering of healthy behaviours could also be a possible reason for the association between ‘breakfast consumption’ and fitness (Aarnio et al., 2002, Cohen et al., 2003).

Regular ‘breakfast consumption’, in our study, was associated with a healthier cardiovascular profile in boys but not in girls. Albertson et al. have shown similar results among children and pre-adolescents (Albertson et al., 2003). To the best of my

knowledge, there are no other studies, among adolescents, examining the relationship between breakfast consumption and blood metabolic variables.

Boys who were 'breakfast consumers' had lower blood pressure regardless of BMI, whereas no association was found in girls. Similar results have been shown among Greek adolescents (Kollias et al., 2009). Calcium has been shown to have a blood pressure lowering effect (Hajjar et al., 2003). The DASH diet (Dietary Approaches to Stop Hypertension), which includes high intakes of fruits and vegetables, low fat milk and grains (recommended for most servings whole grains) has been shown to lower blood pressure among adults (Mitka, 2007). Adolescents who usually consume breakfast are more likely to be frequent consumers of fruit, cereals and milk (Utter et al., 2007).

The results in the literature in combination with our results that only a few adolescents consume a 'high quality breakfast' highlight the importance of promoting breakfast among adolescent.

5.5 Methodological issues

The strengths of the HELENA study include the fact that the geographical distribution of partners, as well as the large sample of adolescents in the study population, gives a fair approximation of the average picture of the situation in the European cities (Moreno et al., 2008). Another strength is the standardised and harmonised methodology (Beghin et al., 2008, Iliescu et al., 2008, Moreno et al., 2008) and the use of reliable and validated questionnaires (Vereecken et al., 2009a). The limitations of the current study include the cluster selection, sampling from urban areas only, the lack of possibility to compare the results between the different countries in Europe (Moreno et al., 2008) and the use of self-reported data (Gilbert et al., 2008, Iliescu et al., 2008, Vereecken et al., 2009a).

Even if the cluster selection was a limitation, the classes in the schools were randomly selected and if one class was removed, the next class on the list, from the same school, was chosen. The replacement classes were of the same type and were supposed to have the same socio-demographical distribution.

The findings in paper II and III were presented for two regions in Europe, but heterogeneity in breakfast habits between European countries even within these regions have been reported (Vereecken et al., 2009b). To get more specific information about

the breakfast habits among European adolescents it is recommended to do investigations in larger country samples.

The skipping breakfast variable, used in paper III and IV was based on the adolescent's perception of how often they skipped breakfast, and therefore not based on real frequencies or food intake. No specific definition for the term 'breakfast' was provided in the papers included in this thesis.

Adjusting for multiple comparisons e.g. Bonferroni correction, could have been one way to control for the risk of Type-I error in the analyses included in the thesis. The problem with Bonferroni correction is that it is based on the null hypothesis, it will be different according to the amount of tests and it increases the Type-II error (Perneger, 1998). The null hypothesis is not appropriate in this thesis. Each test in our study has its own hypothesis and is not related to the amount of analyses. Type-II error (beta error) is a false result but not rejected i.e. falsely negative results. The probability of a type II error is related to the power of the study and that is not a problem in this study. The multiple comparisons have been discussed among epidemiologists and considered to be a misunderstanding (Rothman et al., 2008).

5.6 Conclusion remarks

- Adaptation, translation and standardisation of YANA-C make it possible to assess the dietary intake of adolescents in a broad international context. In general, good agreement between the administration modes was found. The latter offering significant potential for large-scale surveys where the amount of resources to gather data is limited. Nevertheless, a more thorough validation in each participating country against a stronger standard is advocated.
- Few adolescents had a ‘high-quality’ breakfast, although most of them were breakfast consumers. Younger adolescent’s, adolescents from the northern/central part of Europe (Austria, Belgium, France, German and Sweden) and adolescents from families with high socio-demographical status (mother’s with a high education, high FAS, traditional families) were more likely to consume a ‘high-quality’ breakfast.
- Adolescents’ breakfast consumption and choice of food for breakfast was associated with region in Europe; sex; socio-environmental factors (parents) and personal factors (hunger, taste and health) and was inappreciably associated to socio-demographical factors.
- Those who regularly consume breakfast have lower body fat. Regular breakfast consumption was also associated with higher cardiorespiratory fitness in both boys and girls, and with a healthier cardiovascular profile, especially in boys. Eating breakfast regularly may also attenuate the effect of excess adiposity on TC and LDLc in boys.

5.6.1 Public health implication

The public health implications of poor breakfast consumption habits are considerable and the work presented in this thesis highlights the need to promote breakfast, especially a ‘high-quality’ breakfast among adolescents, particularly among older adolescents, adolescents from the southern part of Europe and adolescents from families with low socio-demographical status.

Paper I shows that adaptation, translation and standardisation of a computerised 24-h recall make it possible to assess the dietary intake of adolescents in a broad international context. The program is suitable for dietary surveys, among adolescents, where the amount of time and resources to gather data is limited.

Paper II and III show that parents and peers healthy eating behaviours are associated to the adolescents breakfast consumption. School breakfast programs are considered to be useful (Aranceta et al., 2001, Gassin, 2001), but opinions differ regarding efficiency (Belderson et al., 2003). Studies have indicated the family to be a good arena for breakfast programs (Keski-Rahkonen et al., 2003, Matthys et al., 2007). Our results and the literature suggest that a healthy breakfast, consisting of a variety of foods, namely cereals, fruit/vegetables and dairy products consumed in a family setting on a daily basis may be effective.

Paper IV shows that adolescents who always consume breakfast has a lower mean BMI and are less likely to be obese and have a better cardiorespiratory fitness than those who skip this meal. The importance of cardiorespiratory fitness as a marker of adolescent’s health (Hurtig-Wennlof et al., 2007) and in preventing adult disease (Freedman et al., 2001) adolescents should be encouraged to consume breakfast regularly.

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