INEQUALITIES IN CHILDREN’S ENERGY BALANCE-RELATED BEHAVIOURS: A EUROPEAN PERSPECTIVE

Juan Miguel Fernández Alvira
Inequalities in children's energy balance-related behaviours: a European perspective. PhD thesis; EMGO+ Institute for Care and Health Research VU University Medical Center, Amsterdam, the Netherlands


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INEQUALITIES IN CHILDREN’S ENERGY BALANCE-RELATED BEHAVIOURS: A EUROPEAN PERSPECTIVE

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               dr. S.J. te Velde
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GENERAL INTRODUCTION
Childhood overweight is one of the most serious public health challenges of the 21st century (1), with increasing global prevalence in the last decades at an alarming rate (2). Even if the epidemic seems to be levelling off in some countries (3, 4), it will entail future public health consequences, as overweight and obese children are likely to stay overweight or obese into adulthood (5), and are therefore more likely to develop non-communicable diseases (e.g. diabetes, cardiovascular diseases) at a younger age (6, 7). Because overweight and obesity, as well as their co-morbidities, are largely preventable –while difficult to treat, prevention of childhood overweight and obesity need high priority.

**ENERGY BALANCE-RELATED BEHAVIORS**

Even if some individuals are more genetically susceptible to gain weight (8), there is a consensus that the fundamental causes of the childhood overweight and obesity epidemic are the changes in lifestyle behaviours causing a positive imbalance between energy intake and energy expenditure (9). The energy balance is, in the most general sense, determined by two factors: energy intake (dietary behaviour) and energy expenditure (basal metabolic rate and physical activities). In order to address more specific goals for overweight and obesity prevention among school-aged children, it is necessary to differentiate the most relevant energy balance-related behaviours (EBRBs) in this age group (10). These behaviours comprise, among others, the intake of sugared-sweetened drinks, breakfast skipping, screen viewing behaviour (TV viewing and sedentary computer activities) and regular physical activities, like active commuting to school, participation in sports and recreational physical activity (11-14). In addition, recent evidence suggests that sleeping habits are also relevant for energy balance (15, 16).
ENVIRONMENTAL DETERMINANTS

In the last years, the importance of the “obesogenic environment” has been highlighted. According to the ecological systems theory (17), EBRBs can determine the children's risk of overweight development. However, the impact of children's EBRBs on the development of overweight is shaped by several factors such as parenting styles and family characteristics (e.g. parental EBRBs patterns, nutritional knowledge, child feeding practices and nutrition in early life, siblings and peer interaction). Furthermore, environmental factors such as the characteristics of the school environment (e.g. breaks and facilities for physical activity and nutritional quality of school lunches), community and larger environmental factors, such as parent work-related demands (i.e. work hours and leisure time), ethnic background, national socioeconomic context and the availability and accessibility of recreational facilities, may influence child weight status as a result of their influence children's EBRBs.

Figure 1. Environmental Research framework for weight Gain prevention (EnRG). Kremers, SP et al (18).
In the last years, conceptually refined models of how environment might affect EBRBs have been put forward. The Environmental Research framework for weight Gain prevention (EnRG) (18) was proposed as a dual-process model that can be used to guide research on the determinants of EBRBs and the causal mechanisms that underlie these behaviours (see figure 1). In this framework, behaviour is conceptualized to be the result of simultaneous influence of conscious and unconscious processes in both direct and indirect ways. The EnRG framework has proven to be useful in guiding research on family environmental determinants of EBRBs and overweight and its underlying working mechanisms (19, 20).

INEQUALITIES IN CHILDHOOD OVERWEIGHT

The burden of the overweight and obesity epidemic is not equally distributed across all segments of the population. The prevalence of overweight and obesity is considerably higher among youth from lower socio-economic backgrounds (21-25) and thus likely to augment broader social health inequalities (26, 27). In addition, several reports found associations between several EBRBs and socio-economic status (SES) indicators. A common/frequent factor reported is parental education (28, 29): children with lower educated parents have been reported to drink more sugared drinks (28, 30), be less physically active (31-33) and be more sedentary (34, 35), while mixed results have been found regarding the associations between parental education and sleep duration (36-38). A detailed description of the definition of socio-economic status is provided in Box 1.

Recent studies also assessed differences in childhood overweight and obesity prevalence and EBRBs levels according to ethnicity. American and European studies reported generally higher overweight and obesity prevalence rates in ethnic minorities (39-42). Although ethnicity and SES are strongly associated, there are studies suggesting that both are partly independently associated with health and health-related behaviours (39, 43). A detailed description of the definition of ethnicity is provided in Box 2.

More specifically, several potential explanations for socioeconomic and ethnic differences in childhood overweight in relation to EBRBs have been put forward. Inequalities in access to material and immaterial resources (44, 45) may limit the
availability of healthier foods among disadvantaged groups (26), and differences in the built environment may affect levels of physical activity (46, 47). Furthermore, lower parental education may be associated with less knowledge and skills regarding healthy behaviours (48). In addition, less favourable behavioural patterns in children from lower SES groups may be caused by a less favourable social environment – i.e. less social support, unfavourable social norms or modelling-, such as parental modelling, i.e. because of unfavourable example behaviour from the parents, children tend to be less likely to engage in physical activities and more likely to be sedentary (34, 49-52). Regarding ethnic minorities, the same SES-related explanations may be true, but additional ethnicity-specific cultural factors may induce more unhealthy habits (53-55) that are not completely explained by socio-economic differences (56). However, there is limited evidence quantifying the specific influence of SES and ethnicity in EBRBs and its impact on childhood obesity. Understanding the influence of socio-economic and ethnic variables on the EBRBs patterns leading to obesity is critical to developing effective public policies and interventions to prevent childhood overweight and obesity.

Box 1: Terminology of socio-economic status
Socioeconomic status (SES) is commonly conceptualized as the social standing or class of an individual or group and often being measured taking into account factors such as educational attainment, income or occupation. In this thesis, parental education was selected as an indicator of the children's SES, and information was obtained by parental self-reported questionnaires. One parent (mother or father) was asked to report on the years of education of both parents. The question was: “How many years of school education did you/your partner complete?” and the answering categories were: a) less than 7 years, b) 7-9 years, c) 10-11 years, d) 12-13 years, and e) 14 years or more. These categories took into account the different educational levels, starting from preschool. Thus, category “c” approximately distinguished families with at least one caregiver who has completed medium or higher vocational, college or university training from other families. After preliminary analysis of the distribution of parental education, it was decided to recode the variable into less than 14 years of education and 14 years or more, due to the small sample size included in the lowest categories.
Box 2: Terminology of ethnicity

Ethnic group or ethnicity is a socially defined category based on groups of people whose members identify with each other, through a common heritage, often including a common language and common culture that stresses common ancestry. In this thesis, ethnicity was defined in two ways; a) based on the language spoken at home and b) based on the country of origin of the parents. Language spoken at home was assessed in the child questionnaire and the answering categories were tailored to the different countries, including the official language or languages of the country or region, the native languages of the largest ethnic minorities, and a category “other”. For the analyses, a dichotomous variable was created distinguishing those children for whom the official language of the country of administration was mainly spoken at home (e.g. Greek in Greece, native) from those who reported another language (non-native). Regarding the country of origin of parents, a second dichotomous variable was created, distinguishing children from parents that were both born in the country of administration (native) from those for whom at least one parent was born in another country (non-native).

AIM OF THE THESIS

The work presented in this thesis aims to gain insight into the role of several EBRBs (i.e. sugared-sweetened drinks, breakfast skipping, active transportation to school, sports engagement, TV and computer time and sleep duration) that may explain parental educational and ethnic inequalities in childhood overweight in school-aged children across different countries in Europe.

The work conducted for this thesis is part of a larger research project – i.e. the cross-sectional study of the “EuropeaN Energy balance Research to prevent excessive weight Gain among Youth” (ENERGY)-project (57). The main objectives of the ENERGY cross sectional study were to perform a multidisciplinary analysis of the most important behaviours contributing to the energy balance of children, and their most important modifiable determinants, including personal as well as sociocultural, physical and economic environmental factors, with specific focus on the family and school setting. The studies in this thesis focus on further investigating of potential socio-economic and parental determinants of schoolchildren’s EBRBs, overweight and obesity. Figure 2 displays the conceptual framework of the study and the hypothesized associations and mediating pathways between parental
educational level and ethnicity on the one hand and EBRBs and overweight status on the other hand. To address the main aim of this thesis the following research questions were formulated:

1. Regarding the mediating role of children’s EBRBs in the associations between socioeconomic variables and children’s body composition (part 1):
   a) Are EBRBs mediating variables in the associations between parental education and children’s body composition?
   b) Are EBRBs mediating variables in the associations between ethnic background and body composition?

2. Regarding the associations between parental education and children’s EBRBs (part 2):
   a) How do EBRBs cluster in European children and is there an association with parental education?
   b) Is parental education independently associated with parental physical activity and children’s physical activity?
   c) Are parental sports participation and TV time mediating variables in the associations between parental education and children’s sports participation and TV time?

THE STUDY SAMPLE: THE ENERGY-PROJECT

As already mentioned, the studies described in this thesis have been conducted within the cross-sectional study of the ENERGY project. The cross-sectional study was carried out between March and July 2010 in Belgium, Greece, Hungary, the Netherlands, Norway, Slovenia and Spain, among pupils in the final years of primary education (aged 10-12). The general aim of the cross-sectional study was to provide up to date information on the prevalence of overweight and obesity, on the most important EBRBs and their personal as well as socio-cultural, physical and economic environmental determinants (57, 58). Information on children’s and parent’s EBRBs and socioeconomic variables was obtained using self-reported questionnaires (59, 60). Anthropometric measures were performed by trained researchers or research assistants according to standardized protocols. A total of 7234 children and 6002 parents filled in the questionnaires, while anthropometric measurements were obtained from 7152 children
Figure 2. Conceptual framework and explored associations and mediating pathways in this thesis
Part 1: associations and mediating pathways between socioeconomic determinants, children’s
EBRBs and children’s body composition
Part 2: associations and mediating pathways between socioeconomic determinants, parental
EBRBs and children’s EBRBs; EBRB: energy balance-related behaviour

OUTLINE OF THE THESIS

The first part of the thesis (chapters 2 and 3) focuses on the mediating role of
children’s EBRBs in the associations between socioeconomic determinants and
children’s body composition. Chapter 2 explores the potential mediation effect of
children’s EBRBs in the association between parental education and children’s body
composition (question 1a). Chapter 3 explores the potential mediation effect of
children’s EBRBs in the association between ethnicity background and children’s
body composition in Greek and Dutch subsamples (question 1b). The second part
of the thesis (chapters 4, 5 and 6) focuses on the associations between parental
education and children’s EBRBs and explores if parental behaviour and parental
modelling of two specific behaviours (i.e. physical activity and TV time) can explain
the observed differences in children’s EBRBs. Chapter 4 describes the clustering of
children’s EBRBs and its association with parental education (question 2a). Chapter
5 assesses the association of parental education and parental physical activity with children’s physical activity (question 2b). Chapter 6 explores the potential mediation effect of parental sports and TV time in the association between parental education and children’s sports and TV time, and addresses the differences between parent self-reports and child-reports on parental behaviours (question 2c). Chapters 2 to 6 were written as articles for international peer reviewed journals, and therefore some information regarding, for example, the study design and methodology, show repetition across these chapters. Finally, chapter 7 summarizes the main findings of this thesis, critically discusses theoretical and methodological issues derived from this thesis and ends with the main conclusions and implications for further research and public health.
References
53. Braveman P. The question is not: “is race or class more important?”. J Epidemiol Community Health 2005;59(12):1029.

MEDIATING ROLE OF CHILDREN’S ENERGY BALANCE-RELATED BEHAVIOURS IN THE ASSOCIATIONS BETWEEN SOCIOECONOMIC VARIABLES AND CHILDREN’S BODY COMPOSITION
PARENTAL EDUCATION ASSOCIATIONS WITH CHILDREN’S BODY COMPOSITION: MEDIATION EFFECTS OF ENERGY BALANCE-RELATED BEHAVIORS WITHIN THE ENERGY-PROJECT

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ABSTRACT

Background: It is well known that the prevalence of overweight and obesity is considerably higher among youth from lower socio-economic families, but there is little information about the role of some energy balance-related behaviours in the association between socio-economic status and childhood overweight and obesity. The objective of this paper was to assess the possible mediation role of energy balance-related behaviours in the association between parental education and children's body composition.

Methods: Data were obtained from the cross-sectional study of the “EuropeaN Energy balance Research to prevent excessive weight Gain among Youth” (ENERGY) project. 2121 boys and 2516 girls aged 10 to 12 from Belgium, Greece, Hungary, the Netherlands, Norway, Slovenia and Spain were included in the analyses. Data were obtained via questionnaires assessing obesity related dietary, physical activity and sedentary behaviours and basic anthropometric objectively measured indicators (weight, height, waist circumference). The possible mediating effect of sugared drinks intake, breakfast consumption, active transportation to school, sports participation, TV viewing, computer use and sleep duration in the association between parental education and children's body composition was explored via MacKinnon's product-of-coefficients test in single and multiple mediation models. Two different body composition indicators were included in the models, namely Body Mass Index and waist circumference.

Results: the association between parental education and children's body composition was partially mediated by breakfast consumption, sports participation, TV viewing and computer use. Additionally, a suppression effect was found for sugared drinks intake. No mediation effect was found for active transportation and sleep duration. The significant mediators explained a higher proportion of the association between parental education and waist circumference compared to the association between parental education and BMI.

Conclusions: tailored overweight and obesity prevention strategies in low SES preadolescent populations should incorporate specific messages focusing on the importance of encouraging daily breakfast consumption, increasing sports participation and decreasing TV viewing and computer use. However, longitudinal research to support these findings is needed.
BACKGROUND

Overweight and obesity are important determinants of avoidable burden of disease (1). Despite a levelling-off of obesity prevalence in some countries in the last years, childhood obesity still shows a high prevalence (2). Recent cross-European data from the ENERGY project confirmed these high prevalence rates of overweight and obesity among schoolchildren (3). It is also known that overweight and obesity track from childhood to adulthood (4, 5). Recent research and literature reviews show that, among schoolchildren, some specific energy balance-related behaviours (EBRBs) are associated with overweight and obesity prevalence and may be important for obesity prevention (6-9). These behaviours comprise, among others, the intake of sugared drinks, skipping breakfast, screen viewing behaviour (TV viewing and sedentary computer activities) and lack of regular physical activity, like active commuting to school, participation in sports and recreational physical activity. In addition, recent evidence suggests that sleeping habits may also be relevant for energy balance (10, 11). Despite the associations with overweight, many schoolchildren engage in these risk behaviours (3). It is also well known that the prevalence of overweight and obesity is considerably higher among youth from lower socio-economic families (12-16).

There is little information about the role of those EBRBs in the association between indicators of socio-economic status and childhood overweight and obesity. Morgenstern et al. (17) have recently shown that the effect of socioeconomic status (SES) on overweight was partially mediated by media exposure in children and adolescents aged 10 to 17. Previous studies found that some behavioural factors (e.g. screen time, physical activity and dietary habits) may partially explain the association between SES and excess overweight prevalence, but did not include formal tests of mediation (17-19).

In the ENERGY cohort overweight and obesity were also more prevalent among children from parents with lower levels of education (3). Moreover, the ENERGY project included data on the most important EBRBs. Therefore, the aim of this paper was to assess the possible mediation role of EBRBs in the association between parental education and children’s body composition. More specifically, the current study aims to assess: 1) the total associations of parental education with two different body composition outcomes: Body Mass Index (BMI) and waist circumference; 2) the associations of parental education with EBRBs (i.e. sugared
drinks intake, breakfast consumption, active transportation to school, sports participation, TV viewing, computer use and usual sleep duration) as potential mediating variables; and 3) to assess the mediated pathways of EBRBs on BMI and waist circumference.

**METHODS**

**Study population and design**
Data were obtained from the cross sectional study of the “EuropeaN Energy balance Research to prevent excessive weight Gain among Youth” (ENERGY) project (20). This cross-sectional study was carried out between March and July 2010 in Belgium, Greece, Hungary, the Netherlands, Norway, Slovenia and Spain, among pupils in the final years of primary education (aged 10-12) (21). The aim of the survey was to provide up to date information on the prevalence of overweight and obesity, on the most important energy balance related behaviours (EBRBs) and their social, cognitive and school environmental determinants. Based on previous cross-European studies (22), a minimum sample of 1000 schoolchildren per country and one parent/caretaker for each child were aimed for. The schools were randomly selected concerning the degree of urbanization of the different provinces and the socioeconomic status (SES) of the different areas within the selected provinces. Samples were national in Greece, Hungary, the Netherlands and Slovenia. In Spain, schools of the region of Aragón were selected; Belgium selected schools from Flanders and Norway selected schools from the southern regions of the country (21). Descriptions of the rationale and design of the entire ENERGY project (20) and the procedures and methodology of the ENERGY school-based survey(21) are published elsewhere. All participants provided written informed consent prior their enrolment. The studies were approved by the corresponding local ethics committees in all participating countries.

**Measures**
Measurements were conducted following standardized protocols. The children and the parents were asked to complete printed questionnaires assessing obesity related dietary, physical activity and sedentary behaviours, as well as potential determinants of engaging in these behaviours. The questionnaires and anthropometric measurements were completed during school hours. Test-retest reliability was tested
by administering the questionnaire twice with a one-week interval among 720 schoolchildren across the participating countries. In the paragraphs hereafter information on the intraclass correlation coefficients (ICC) is provided for the specific included items. Detailed information regarding the procedures, staff training and questionnaires development (21), and test-retest reliability and construct validity of the questionnaires are published elsewhere (23, 24).

Anthropometric measurements
Body height, weight and waist circumference were measured by trained research assistants. Children were measured in light clothing without shoes. Body height was measured with a SECA Leicester Portable stadiometer (to the nearest 0.1 cm). Weight was measured with a calibrated electronic scale SECA 861 (to the nearest 0.1 kg), and waist circumference with a SECA 201 measuring band (to the nearest 0.1 cm). Two readings of each measurement were obtained. A third measurement was taken if the two readings differed more than 1%. Body Mass Index (BMI) and weight categories based on the International Obesity Task Force criteria (IOTF)(25) were calculated.

Parental educational level
As an indicator of socio-economic status, the parent respondents were asked to report their own level of education, as well as the level of education of the other parent/caregiver. Because educational systems differ considerably across Europe, years of formal education since preschool were used as the indicator for level of education. Answer categories were as follows: a) less than 7 years, b) 7-9 years, c) 10-11 years, d) 12-13 years and e) 14 years or more. After preliminary analyses of the distribution of the variable, it was concluded that to recode into low, medium and high parental education level was not possible due to the small sample size in the low category. Thus, parental education was categorized as being high (at least one parent more than 14 years of education) or low (both parents less than 14 years of education), which approximately distinguishes families with at least one caregiver who has completed medium or higher vocational, college or university training from other families.

Children’s energy balance-related behaviours
Sugared drinks consumption, breakfast consumption, active transportation, sports participation, TV viewing and computer use were reported by the children, while sleep duration was reported by the parents.
Dietary behaviours
Intakes of soft drinks and fruit juices were assessed with two food frequency questions. Children answered how many days per week they drank the beverage, answering on a seven-point scale from never to more than once every day. Afterwards they were asked to indicate how much they drank by ticking the number of glasses or small bottles (e.g. 250 ml), cans (i.e. 330 ml) and large bottles (i.e. 500 ml) for soft drinks, or glasses/small cartons (i.e. 250 ml) and regular cartons (330 ml) for fruit juices. The questionnaire included pictures of the serving sizes. These items showed moderate to good reliability (intraclass correlation coefficients \( \text{ICC}_{\text{test-retest}} \) between 0.53 – 0.71). Mean intake in ml per day was calculated from these two questions. In addition, children were asked to fill in how much of the beverages they had consumed on the day before, following the same classification. For the purposes of this analysis, litres/day of sugared drinks (soft drinks + fruit juices) were taken into account. Breakfast consumption was assessed with two food frequency questions. Children answered how many days they usually eat breakfast during school days (\( \text{ICC}_{\text{test-retest}} = 0.73 \)) and in the weekend (\( \text{ICC}_{\text{test-retest}} = 0.52 \)). For the purposes of this analysis, total weekly days having breakfast were taken into account.

Physical activity behaviours
Active transportation to school was assessed by two questions about how many days per week the child cycled and/or walked to school (\( \text{ICC}_{\text{test-retest}} = 0.94 \) and 0.91), ranging from never to 5 days/week, and two questions on the duration of biking or walking to school, with 4 answer categories ranging from 1-5 minutes to more than 15 minutes (\( \text{ICC}_{\text{test-retest}} = 0.81 \) and 0.70). Total active transportation time per week was calculated by adding up total bike and walk times and multiplying the number of days with the mean time of the answering category times 2. Organized sports participation was assessed with specific questions about how many hours per week children participated in one or two sports (\( \text{ICC}_{\text{test-retest}} = 0.74 \) and 1.00). Based on the answers, average time of sports participation per week was calculated. Finally, minutes/week of active transportation and hours/week of sports participation were included in the analysis.

Sedentary behaviours
Screen time (i.e. TV and computer time) was assessed separately for weekdays and weekend days by two questions about time spent watching TV (including video and DVD) (\( \text{ICC}_{\text{test-retest}} = 0.67 \) and 0.68) and computer activities (\( \text{ICC}_{\text{test-retest}} = 0.67 \)
and 0.67). Mean TV, computer and total screen time per day were calculated. For the analysis, total hours/week of TV viewing and total hours/week of computer use were taken into account.

Sleep duration. Child’s sleep duration reported by the parents included the number of hours the child sleeps per night on average, separately for weekdays (ICC_{test-retest} = 0.81) and weekend days (ICC_{test-retest} = 0.78). For the purpose of this paper, only weekdays (hours/day of sleep duration) were taken into account as sleep during weekdays is likely to be more representative of usual sleep duration, due to the more regular bed- and get-up routine(11).

Statistical analysis
Means and standard deviations were calculated for the key variables, separately for boys and girls. A complete cases design was used; therefore only children having valid data for the variables included in the analysis were taken into account. Children not included in the final analysis had slightly lower BMI and were slightly older compared to the included sample (data not shown). Multilevel analysis intraclass correlation coefficients (ICCs) were calculated, in order to check whether a school level clustered design was needed. The obtained school ICCs were low (all <0.06), reflecting no clustering effect at school level. Therefore, the analyses were adjusted only for country level.

Mediation analysis
To assess whether the associations between parental education and body composition outcomes were mediated by the EBRBs, the product-of-coefficients test proposed by MacKinnon was performed (26). To qualify as a mediator, the presumed mediator has to be associated with the predictor variable and with the outcome variable (27). To define the final regression models, the included EBRBs, as the presumed mediators, had to fulfil two requirements: (1) the parental education indicator (X) has to be associated with the mediator (M) (path a); and (2) the mediator has to be associated with the body composition outcome (Y) in a regression model adjusted for the predicting variable (X) (path b) (see Figure 1).
Figure 1. Multiple mediator model.

X: predictor variable; Y: outcome variable; Mj: mediator variable; a\textsubscript{j}: association between predictor (X) and potential mediator (Mj); b\textsubscript{j}: association between potential mediator (Mj) and outcome variable (Y); c: overall association between predictor variable (X) and outcome variable (Y); c': direct effect (unmediated) of predictor variable (X) on outcome variable (Y); BMI: Body Mass Index; WC: Waist Circumference.

The potential mediators meeting these criteria were included in the final multiple mediator models and mediation effects and mediated proportions were calculated. The product-of-coefficients method (a\textsubscript{i} b\textsubscript{j}) was used to calculate the mediated effect. The total mediated effect was calculated as the sum of the individual mediated effects (S[a\textsubscript{i} \times b\textsubscript{j}]). The mediated proportions were calculated as the mediation effect divided by the total effect (path c) ([a\textsubscript{i} \times b\textsubscript{j}] / c) and (S[a\textsubscript{i} \times b\textsubscript{j}] / c). Total effects were estimated by regression models without the potential mediators. Standard errors were calculated and used to construct the 95% confidence intervals (CI) for the direct and total effects. Bootstrap corrected CI were used for indirect, mediated, effects by means of the SPSS macro developed by Preacher and Hayes(28).

All regression models were adjusted for potential confounders (gender, age, country). Additionally, a potential effect modification of the total association by gender was assessed using an interaction term (gender*parental education). In case of significant interaction term, analysis would be stratified by sex. Analyses were conducted using IBM SPSS Statistics 19.
RESULTS

Table 1 describes the basic characteristics of the eligible children (2121 boys and 2516 girls). Differences on sugared drinks consumption, sports participation, TV viewing and computer use were found according to gender, while active transportation, breakfast consumption and sleep duration did not differ. Boys reported higher intake of sugared drinks, higher sports participation and higher TV and computer use compared to girls. There was also a higher proportion of overweight boys compared to girls, but no differences in obesity prevalence(3).

Table 1. Descriptive statistics of the study sample, by sex.

<table>
<thead>
<tr>
<th></th>
<th>Boys</th>
<th>Girls</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N=4637</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2121</td>
<td>2516</td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>Mean 11.6</td>
<td>Mean 11.6</td>
<td>0.089</td>
</tr>
<tr>
<td></td>
<td>SD 0.73</td>
<td>SD 0.73</td>
<td></td>
</tr>
<tr>
<td>Sugared drinks (day/day)</td>
<td>0.63</td>
<td>0.52</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Breakfast (days/week)</td>
<td>6.02</td>
<td>5.95</td>
<td>0.179</td>
</tr>
<tr>
<td>Active transportation (min/week)</td>
<td>53.55</td>
<td>54.95</td>
<td>0.408</td>
</tr>
<tr>
<td>Sports participation (hours/week)</td>
<td>4.23</td>
<td>3.3</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>TV viewing (hours/week)</td>
<td>13.43</td>
<td>12.49</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Computer use (hours/week)</td>
<td>10.52</td>
<td>7.71</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Sleep duration (hours/day)</td>
<td>9.05</td>
<td>9.07</td>
<td>0.388</td>
</tr>
<tr>
<td>High parental education (n [%])</td>
<td>n 1449</td>
<td>n 1690</td>
<td>0.698</td>
</tr>
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<td>Normalweight (n [%])</td>
<td>n 1548</td>
<td>n 1975</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Overweight (n [%])</td>
<td>n 466</td>
<td>n 441</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Obese (n [%])</td>
<td>n 107</td>
<td>n 100</td>
<td>0.092</td>
</tr>
</tbody>
</table>

Parental education and children’s body composition (c-path)

Analyses for effect modification by sex did not show significant results (all p-values > 0.324). Subsequently, all analyses below are presented for boys and girls together. The results showed that parental education was significantly inversely related with BMI ($\beta$=-0.43; CI: -0.64, -0.23) and waist circumference ($\beta$=-0.94; CI: -1.47, -0.41).
Associations between parental education and energy balance-related behaviours (a-path)
As described in tables 2 and 3 significant associations with parental education were found for sugared drinks, breakfast consumption, sports participation, TV viewing and computer use (all \( p<0.001 \)). Parental education was positively associated with sports participation and breakfast consumption, while sugared drinks, TV viewing and computer use were negatively associated with the parental education. Parental education was negatively associated with active transportation in the BMI model, but not in the waist circumference model.

Associations between energy balance-related behaviours and children’s body composition (path-b)
TV viewing and computer use were positively associated with both BMI and waist circumference, while sports participation, breakfast consumption and sleep duration were negatively associated with both BMI and waist circumference (all \( p<0.01 \)). Sugared drinks consumption was also negatively associated with BMI (\( p<0.05 \)), but not with waist circumference. These variables were selected to be included in the final multiple mediator models, as shown in the third column of table 2 and 3.

Mediation effects (a*b)
The fourth and sixth columns of tables 2 and 3 show the estimated mediation effects and the proportion mediated. Indirect effects (see figure 1) were statistically significant for breakfast consumption, sports participation, TV viewing and computer use in both models, and for sugared drinks in the BMI model. The mediated proportions varied, with the highest proportion for breakfast consumption (12.6%-13.5%) and the smallest for computer use (5.4%-7.4%). The total proportions of the overall effect mediated by all the mediators were 18.7% for the BMI model and 35.8% for the waist circumference model. Sugared drinks consumption had a suppressive effect on the relationship between parental education and BMI (-6.1%), due to opposite directions of the direct and indirect associations.

Direct association (path-c’)
As can be seen in Tables 2 and 3, there were significant direct associations between parental education and BMI and waist circumference, after inclusion of the presumed mediators in the model.
Table 2. Results from the mediation analyses in the association between parental education and BMI (kg/m²)

<table>
<thead>
<tr>
<th>Mediator:</th>
<th>Parental education effect on mediator (path a) (95% CI)</th>
<th>Single mediator effect on BMI (path b) (95% CI)</th>
<th>Multiple mediator model (path b) (95% CI)</th>
<th>Indirect effect (a*b) (95% CI)</th>
<th>Direct effect (path c') (95% CI)</th>
<th>% Mediated (a*b/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total association (c) (95% CI):</td>
<td>-0.43 [-0.64 ; -0.23]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sugared drinks (l/day): p-value</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breakfast (days/week): p-value</td>
<td>0.26 [-0.001 ; 0.211]</td>
<td>(-0.211 ; 0.001)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active transportation (min/week):</td>
<td>-3.63 [-0.034 ; 0.001]</td>
<td>0.001 [-0.889 ; 0.001]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sports participation (hours/week):</td>
<td>0.5 [-0.001 ; 0.002]</td>
<td>(-0.002 ; 0.002)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TV viewing (hours/week): p-value</td>
<td>1.127 [-0.001 ; 0.28]</td>
<td>0.028 [-0.001 ; 0.024]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer use (hours/week): p-value</td>
<td>-1.19 [-0.001 ; 0.006]</td>
<td>0.02 [-0.205 ; 0.001]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sleep duration (h/day): p-value</td>
<td>-0.04 [-0.014 ; 0.016]</td>
<td>-0.309 [-0.001 ; 0.001]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All significant mediators p-value</td>
<td>-0.09 [-0.01 ; 0.011]</td>
<td>(-0.426 ; 0.192)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For an explanation of a, b, c, c': please see Figure 1
All models were adjusted for age, gender and country
Statistically significant associations are shown in bold
Table 3. Results from the mediation analyses in the association between parental education and waist circumference (cm)

<table>
<thead>
<tr>
<th></th>
<th>Parental education effect on mediator (path a) (95% CI)</th>
<th>Single mediator effect on WC (path b) (95% CI)</th>
<th>Multiple mediator model (path b) (95% CI)</th>
<th>Indirect effect (a*b) (95% CI)</th>
<th>Direct effect (path c') (95% CI)</th>
<th>Mediated (a<em>b</em>c) %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total association (c) (95% CI)</td>
<td>-0.94 (-1.47; -0.41)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mediator:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sugared drinks</td>
<td>-0.14 &lt;0.001</td>
<td>-0.085 0.693</td>
<td>0.01</td>
<td>-0.95</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>(l/day); p-value</td>
<td>(-0.18; -0.11)</td>
<td>(-0.504; 0.335)</td>
<td>(-0.05; 0.07)</td>
<td>(-1.48; -0.42)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breakfast</td>
<td>0.26 &lt;0.001</td>
<td>-0.484 &lt;0.001</td>
<td>-0.444 &lt;0.001</td>
<td>-0.13</td>
<td>-0.81</td>
<td>0.003</td>
</tr>
<tr>
<td>(days/week); p-value</td>
<td>(0.15; 0.37)</td>
<td>(-0.622; -0.346)</td>
<td>(-0.582; -0.305)</td>
<td>(-0.20; -0.06)</td>
<td>(-1.34; -0.28)</td>
<td>13.5</td>
</tr>
<tr>
<td>Active transportation</td>
<td>-3.74 0.029</td>
<td>-0.002 0.489</td>
<td>0.01</td>
<td>-0.96</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>(min/week); p-value</td>
<td>(-7.09; 0.39)</td>
<td>(-0.006; 0.003)</td>
<td>(0.01; 0.04)</td>
<td>(-1.49; -0.43)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sports participation</td>
<td>0.5 &lt;0.001</td>
<td>-0.231 &lt;0.001</td>
<td>-0.219 &lt;0.001</td>
<td>-0.12</td>
<td>-0.96</td>
<td>0.002</td>
</tr>
<tr>
<td>(hours/week); p-value</td>
<td>(0.34; 0.67)</td>
<td>(-0.323; -0.139)</td>
<td>(-0.311; -0.128)</td>
<td>(-0.18; -0.06)</td>
<td>(-1.49; -0.43)</td>
<td>12.4</td>
</tr>
<tr>
<td>TV viewing</td>
<td>-1.26 &lt;0.001</td>
<td>0.089 &lt;0.001</td>
<td>0.068 0.001</td>
<td>-0.11</td>
<td>-0.83</td>
<td>0.002</td>
</tr>
<tr>
<td>(hours/week); p-value</td>
<td>(-1.69; -0.83)</td>
<td>(0.053; 0.124)</td>
<td>(0.029; 0.107)</td>
<td>(-0.19; -0.06)</td>
<td>(-1.36; -0.30)</td>
<td>11.9</td>
</tr>
<tr>
<td>Computer use</td>
<td>-1.19 &lt;0.001</td>
<td>0.058 0.002</td>
<td>0.019 0.342</td>
<td>-0.07</td>
<td>-0.87</td>
<td>0.001</td>
</tr>
<tr>
<td>(hours/week); p-value</td>
<td>(-1.61; -0.78)</td>
<td>(0.021; 0.095)</td>
<td>(-0.021; 0.059)</td>
<td>(-0.14; -0.03)</td>
<td>(-1.40; -0.34)</td>
<td>7.4</td>
</tr>
<tr>
<td>Sleep duration</td>
<td>-0.04 0.105</td>
<td>-0.676 &lt;0.001</td>
<td>0.03</td>
<td>-0.97</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>(h/day); p-value</td>
<td>(-0.09; 0.01)</td>
<td>(-0.981; -0.370)</td>
<td>(-0.01; 0.08)</td>
<td>(-1.49; -0.44)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All significant mediators p-value</td>
<td>-0.34 -0.6</td>
<td>(-0.46; -0.23) (-1.13; -0.07)</td>
<td>35.8</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For an explanation of a, b, c, c', please see Figure 1
All models were adjusted for age, gender and country

Statistically significant associations are shown in bold
DISCUSSION

The present study aimed to explore the mechanisms through which parental education differences are associated with children’s body composition. Current results first confirmed that parental educational level was inversely associated with children's BMI and waist circumference. Next, the results showed that the association between parental education and children's body composition was partially mediated by certain EBRBs, namely breakfast consumption, sports participation, TV viewing and computer use. Additionally, a suppression effect was found for sugared drinks intake. No mediation effect was found for active transportation and sleep duration.

Although previous studies looked at the separate relationships and not at the mediation effect, the results are in line with previous reports in which higher parental education was associated with lower childhood overweight indices (29, 30). The associations between parental education and the EBRBs are also in line with available literature showing a negative association between several SES-indicators (including parental education) and breakfast skipping (31), sedentary habits (32), sugared drinks intake (33) and active transportation (34), and a positive association between SES and physical activity (32).

The current results on the association between the different EBRBs and the body composition outcomes are also in agreement with previous reports. Physical activity level, TV viewing, sugared drinks intake, breakfast consumption and sleep duration have been clearly associated with childhood overweight, while computer use was found to be related only in some studies (9, 35-38). Previous reports on the association between active transportation and overweight did not show a consistent relationship (18, 39).

Although sleep duration has been associated negatively with childhood overweight – which was also confirmed in the present data -, the current analysis did not show a mediation effect of sleep duration, due to a non-significant association between parental education and sleep duration. In contrast, parental education was associated with active transportation, but active transportation was not associated with body composition indices. Recent reports showed positive associations between parental education and cycling to school while negative associations between cycling to school and overweight have been reported (40, 41). Therefore,
the single mediation analysis was also repeated for the two active transportation categories separately, in order to look at the specific trends. We found a negative association between parental education and walking to school but no association between parental education and cycling to school. In both cases no association with body composition indices was found (data not shown).

A suppression effect was found for sugared drinks intake. This effect could be due to a lower intake of sugared drinks in overweight children, or a higher impact of underreporting in this group (42-44). It is also noteworthy that sugared drinks consumption was a suppressor only in the BMI model, but not in the waist circumference model.

The analyses included two different body composition indicators, namely BMI and waist circumference. The significant mediators explained 36% of the relationship between parental education and waist circumference, while only 19% of the relationship between parental education and BMI was explained. This finding could reflect the differences between BMI and waist circumference as measures of childhood adiposity. Waist circumference has been observed in cross-sectional studies to be a good abdominal fat estimate (45), a better predictor of cardiovascular disease risk factors in childhood (46, 47), and to predict metabolic health risk in adults beyond that explained by BMI(48, 49).

To our knowledge, this is one of the first studies trying to disentangle the complex interaction between parental education, several EBRBs and children’s body composition by applying mediation analysis. The proportion of the associations explained by the included mediators in both models was moderate, i.e. the association remained significant after adjusting for the mediators. These results suggest that other variables not included in the analyses may play a mediating role in the relationship between parental education and children’s body composition. Future analyses including other potential mediators, not only behavioural but also environmental factors, like availability or accessibility, could enhance the knowledge about the complex relationship between parental education and children’s body composition.

It has to be kept in mind that this study is subject to some limitations. First, this concerns a cross-sectional study providing evidence for associations but not causation. Further, data on dietary, physical activity and sedentary behaviours were based on self-reports, and thus possibly biased. However, the measures showed
good test-retest reliability and construct validity (23, 24). When considering
sedentary behaviours it is also important to note that some sedentary activities, like
reading or studying were not included in the present study. It is therefore very likely
that questionnaires did not reflect the real, total time spent in sedentary behaviours.
Parental education was reported taking into account both parents, and therefore
we were not able to assess the differential influence of paternal and maternal
educational levels on children’sEBRBs. Although the use of central adiposity
indicators like waist circumference is useful as a good predictor of future health
problems, it could be helpful to control for the maturation level when assessing
pre- and adolescent population(50). Unfortunately, no information on maturation
level was collected in the ENERGY cross-sectional study. Finally, the differences
between selected participants and those not included in the analysis may influence
the generalizability of the results. However, differences were small and, although
significant, probably not relevant. Strengths of the present study include the large
multinational sample from different regions across Europe, the available measured
weight, height and waist circumference and the standardized data collection
protocol across the different centres.

CONCLUSIONS

The association between parental education and children’s body composition was
partially mediated by breakfast consumption, sports participation, TV viewing and
computer use. The significant mediators explained a higher proportion of the
association between parental education and waist circumference compared to the
association between parental education and BMI. Tailored overweight and obesity
prevention strategies in low SES preadolescent populations should develop specific
messages focusing on the importance of encouraging daily breakfast consumption,
increasing sports participation and decreasing TV viewing and computer use.

ACKNOWLEDGEMENTS

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References


CAN ETHNIC BACKGROUND DIFFERENCES IN CHILDREN’S BODY COMPOSITION BE EXPLAINED BY DIFFERENCES IN ENERGY BALANCE-RELATED BEHAVIOURS? A MEDIATION ANALYSIS WITHIN THE ENERGY-PROJECT

Juan Miguel Fernández-Alvira, Saskia te Velde, David Jiménez-Pavón, Yannis Manios, Amika Singh, Luis A Moreno, Johannes Brug

**ABSTRACT**

**Background:** In affluent countries, children from non-native ethnicity have in general less favourable body composition indicators and energy balance-related behaviours (EBRBs) than children from native ethnicity. However, differences between countries have been reported.

**Methodology/Principal Findings:** A school-based survey among 10-12 years old children was conducted in seven European countries with a standardized protocol. Weight, height and waist circumference were measured; engagement in EBRBs was self-reported. For those countries with significant ethnic differences in body composition (Greece and the Netherlands), multilevel mediation analyses were conducted, to test the mediating effect of the EBRBs in the association between ethnic background and body composition indicators. Analyses were adjusted for gender and age, and for parental education in a later step. Partial mediation was found for sugared drinks intake and sleep duration in the Greek sample, and breakfast in the Dutch sample. A suppression effect was found for engagement in sports activities in the Greek sample.

**Conclusions/Significance:** Ethnic differences in children’s body composition were partially mediated by differences in breakfast skipping in the Netherlands and sugared drinks intake, sports participation and sleep duration in Greece.
INTRODUCTION

Childhood overweight and obesity are a major public health issue in many parts of the world (1). The obesity epidemic does not affect all segments of the population equally. Differences according to socio-economic position or level of education have been well documented (2, 3), also for school-aged children (4, 5). Recent American (6, 7) and European (8-10) studies show ethnic inequalities in childhood overweight and obesity prevalence (6, 7, 11-16) and energy balance-related behaviors (EBRBs) (7, 17-21) with ethnic minorities showing higher prevalence rates. A recent publication (22) on the results of the cross-sectional study of the “EuropeaN Energy balance Research to prevent excessive weight Gain among Youth” (ENERGY)-project (23) also showed that children of native ethnicity of the country of residence had, in general, more favorable weight status indicators and EBRBs than children of non-native ethnicity across seven countries in Europe. However, interesting differences were observed between countries. Most importantly, the largest differences between native and non-native children were found in the Netherlands. In the Netherlands, the prevalence of overweight among non-native children was almost twice the prevalence among native Dutch children (26% vs. 15%). Conversely, an opposite pattern (e.g. significantly lower Body Mass Index (BMI) and waist circumference (WC) in non-native children compared to native children) was observed in the Greek sample.

In order to understand what behaviors may drive and explain these inequalities, it is of special interest to study the underlying mechanisms in the countries where we found differences between native and non-native groups (e.g. Greece and the Netherlands). Understanding if and how different EBRBS may be associated with ethnic differences in body composition may help to tailor preventive intervention initiatives aiming at reducing these ethnic inequalities. These underlying mechanisms can be assessed by mediation analyses (24) (see figure 1).

The current study therefore aims to assess if specific EBRBs mediate the association between ethnicity and body composition indicators found in the Dutch and Greek subsamples of the ENERGY cross-sectional study (22). More specifically and following the stepwise approach for mediation analyses, the aims are: 1) to assess the total associations of ethnic background (see figure 1) with two different body composition outcomes: BMI and WC (c path); 2) to assess the associations of ethnic background with EBRBs as potential mediating variables (a path); and 3) to assess
the mediated pathways of EBRBs on BMI and WC (a*b).

![Diagram](image)

Figure 1. Mediation model. X: predictor variable; Y: outcome variable; M: mediator variable; a path: association between predictor (X) and potential mediator (M); b path: association between potential mediator (M) and outcome variable (Y); c: overall association between predictor variable (X) and outcome variable (Y); c̅: direct effect (unmediated) of predictor variable (X) on outcome variable (Y).

**METHODS**

**Study population and design**

Data were obtained from the cross-sectional study of the ENERGY project (23). This cross-sectional study was carried out between March and July 2010 in Belgium, Greece, Hungary, the Netherlands, Norway, Slovenia and Spain, among pupils in the final years of primary education (aged 10-12) (25). Samples were national representative both in Greece and in the Netherlands (along with Hungary and Slovenia). The aim of the survey was to provide up to date information on the prevalence of overweight and obesity, on the most important EBRBs and their socio-demographic, personal and family- and school-environmental correlates. Descriptions of the rationale and design of the entire ENERGY project (23) and the procedures and methodology of the ENERGY school-based survey are published elsewhere (25). As mentioned before, the prevalence rates of overweight, obesity and engagement in different EBRBs, as well as differences in these prevalences according to parental education and ethnicity, have been published before (5, 22). The study was performed following the ethical guidelines of the
Declaration of Helsinki 1964 (revision of Edinburgh 2000), the Good Clinical Practice, and the legislation about clinical research in humans in each of the participating countries. All participating countries obtained ethical clearance from the relevant ethical committees and ministries. In Greece the survey was approved by the Bioethics Committee of Harokopio University and in the Netherlands the survey was approved by the Medical ethics Committee of the VU University Medical Center; In addition, research permission was obtained, if necessary from local school authorities. A school recruitment letter was sent to the headmaster or principal of the sampled schools. After school’s agreement, parents received a letter explaining the study purpose and were asked for written consent for their child’s and own participation.

**Measures**

Measurements were conducted following standardized protocols. The children and their parents were asked to complete questionnaires assessing obesity related dietary, physical activity and sedentary behaviors, as well as potential determinants of engaging in these behaviors. Test-retest reliability and construct validity were tested by administering the questionnaire twice with a week interval among 720 children across the participating countries. The intraclass coefficients and percentage agreement was good to excellent for 77% of items and construct validity was moderate to excellent for 73% of items (26). Detailed information regarding the procedures, staff training and questionnaires development (25) and test-retest reliability and construct validity of the questionnaires are published elsewhere (26, 27).

**Anthropometric measurements**

Body height, weight and WC were measured by trained research assistants. Children were measured in light clothing without shoes. Body height was measured with a SECA Leicester Portable stadiometer (to the nearest 0.1 cm). Weight was measured with a calibrated electronic scale SECA 861 (to the nearest 0.1 kg), and WC with a SECA 201 measuring band (to the nearest 0.1 cm). Two readings of each measurement were obtained. A third measurement was taken if the two readings differed more than 1%. BMI  [calculated as body weight (kg) divided by the height (m) squared (kg/m²)].
**Ethnic background**
Regarding ethnic background we made a distinction between children of immigrant origin (non-native) and children of native origin in the country of administration based on the language spoken at home and (28). We assessed in the child questionnaire which language was mostly spoken in the home environment of the child. The answering categories were tailored to the different countries, including the official language or languages of the specific country or region, the native languages of the largest ethnic minorities, and a category ‘other’. We created a dichotomous variable distinguishing those children for whom the official language of the country of administration was mainly spoken at home (e.g. Greek in Greece; Dutch in the Netherlands, native) from those who reported another language as the main language at home (non-native).

**Children’s EBRBs**
Sugared drinks consumption, breakfast consumption, active transport, sports participation, TV viewing and computer use were assessed by the child self-report, while sleep duration was reported by the parents. These specific behaviors were selected based on a review study conducted within the ENERGY project of earlier prospective studies on EBRBs in association with overweight indicators (29).

**Dietary behaviors**
Intakes of soft drinks and fruit juices were assessed with two food frequency questions. Children answered how many days per week they drank soft drinks (ICC_{test-retest}=0.71) and fruit juices (ICC_{test-retest}=0.64) answering on a seven-point scale from never to more than once every day. Afterwards they were asked to indicate how much they drank by reporting the number of glasses or small bottles (e.g. 250 ml), cans (i.e. 330 ml) and large bottles (i.e.500 ml) for soft drinks, or glasses/small cartons (i.e.250 ml) and regular cartons (330 ml) for fruit juices. The questionnaire included pictures of the serving sizes. These items showed moderate to good reliability (ICC_{test-retest}=0.53 – 0.71). Mean intake in ml per day was calculated from these two questions. In addition, children were asked to fill in how much of the beverages they had consumed on the day before, following the same classification. For the purposes of this analysis, liters/day of sugar-containing drinks (soft drinks + fruit juices) were taken into account. Breakfast consumption was assessed with two food frequency questions. Children answered how many days they usually eat breakfast during school days (ICC_{test-retest}=0.73) and in the weekend (ICC_{test-retest}=0.52). Breakfast frequency per week was calculated by adding up the
answers of the two previous questions. For the purposes of this analysis, the frequency was recoded into 0 (had breakfast 0-6 times week) and 1 (had breakfast 7 days week).

**Physical activity**
Active transportation to school was assessed by two questions about how many days per week the child cycled and/or walked to school ($\text{ICC}_{\text{test-retest}}=0.94$ and 0.91), ranging from never to 5 days/week, and two questions on the duration of biking or walking to school, with 4 answer categories ranging from 1-5 minutes to more than 15 minutes ($\text{ICC}_{\text{test-retest}}=0.81$ and 0.70). Total active transportation time per week was calculated by adding up total bike and walk times and multiplying the number of days with the mean time of the answering category times 2. Organized sports participation was assessed with specific questions about how many hours per week children participated in one or two sports ($\text{ICC}_{\text{test-retest}}=0.74$ and 1.00). Based on the answers, average time of sports participation per week was calculated. Finally, minutes/day of active transportation and min/day of sports participation were included in the analysis.

**Screen behaviors**
Screen time (i.e. TV and computer time) was assessed separately for weekdays and weekend days by two questions about time spent watching TV (including video and DVD) ($\text{ICC}_{\text{test-retest}}=0.67$ and 0.68) and computer activities ($\text{ICC}_{\text{test-retest}}=0.67$ and 0.67). Mean TV, computer and total screen time per day were calculated. For the analysis, total hours/day of screen time were taken into account.

**Sleep duration**
Child’s sleep duration reported by the parents included the number of hours the child sleeps per night on average, separately for weekdays ($\text{ICC}_{\text{test-retest}}=0.81$) and weekend days ($\text{ICC}_{\text{test-retest}}=0.78$). Mean number of hours of sleep per day was calculated.

**Parental educational level**
As an indicator of socio-economic status, we asked the parents to report their own level of education, as well as the level of education of the other parent/caregiver. Because educational systems differ considerably across Europe, the number of years of formal education was used as the indicator for level of education. Parental education was categorized as being high (i.e. at least one parent more than 14 years
of education) or low (i.e. both parents less than 14 years of education), which approximately distinguishes families with at least one caregiver who has completed medium or higher vocational, college or university training from other families (30).

**Statistical analysis**

Descriptive statistics and unadjusted analyses (MANOVA and Chi square tests) were performed using the Statistical Package for the Social Sciences (SPSS) (Version 20.0, SPSS Inc., Chicago, IL). Logistic regression analyses were conducted to check whether non-response was associated with the ethnicity indicator and other basic characteristics (e.g. gender, BMI).

**Mediation analysis**

To assess whether the associations between ethnicity and body composition outcomes were mediated by the EBRBs, mediation analyses were conducted following a stepwise approach. Because children were nested within schools and some of the ICCs were higher than 0.05, multilevel linear regression analyses were performed to assess associations between the ethnicity indicator, body composition and potential mediators using Mplus software (Version 6.11, Muthén & Muthén). Steps 2 – 4 were conducted in Mplus (31) using the INDIRECT command and adjusting for the clustered design (children nested in schools, using the CLUSTER command).

Step 1: although a significant overall association (c-path) is not a prerequisite for conducting mediation analyses, in this study we only assessed potential underlying pathways if a significant difference in body composition outcomes between native and non-native children was observed. These analyses were conducted before (22) and based on these previous observations, we included only the Greek and Dutch subsamples, as the association between language spoken at home and body composition indicators was not significant in the rest of the participating countries (22).

Step 2: to qualify as a mediator, the presumed mediator (M) has to be associated with the predictor variable (a-path) (32). This was assessed by regressing the potential mediators (M, the EBRBs) on the ethnicity indicator (X) as an independent dichotomous variable (non-native = 0, native = 1).
Step 3: to qualify as a mediator, the presumed mediator (M) has also to be associated with the outcome (Y, b-path). This was assessed by regressing the outcome variables (body composition indicators) on the mediators (EBRBs).

Step 4: to estimate the mediated effect (a*b) the product-of-coefficients test proposed by MacKinnon was performed (33) (see Figure 1). The mediated proportions were calculated as the mediation effect divided by the total effect (path c) ([a_i*b_j]/c). Total effects were estimated by regression models without the potential mediators. Standard errors were calculated and used to construct the 95% confidence intervals (CI) for the direct and total effects.

Step 5: finally, direct associations between the ethnicity indicator and body composition indicators were assessed including the mediators in the models.

All steps were adjusted for age and gender in a first step, and also including parental education in a second step. Due to the low parental participation rate in the Dutch sample (less than 50%) models adjusted for parental education will be presented only for the Greek sample.
RESULTS

Participant characteristics
The total sample comprised 2002 children (Table 1). The large majority of children were of native ethnicity. Non-native children presented significantly higher BMI and WC in the Dutch sample and significantly lower BMI and WC in the Greek sample. Non-native groups showed a significantly higher percentage of lower educated parents in both Greek and Dutch subsamples (Table 1).

<table>
<thead>
<tr>
<th>Greece</th>
<th>Non-native</th>
<th>Native</th>
<th>P value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>N (%)</td>
<td>108 (10.0)</td>
<td>975 (90.0)</td>
<td></td>
</tr>
<tr>
<td>Age (mean, SD)</td>
<td>11.4</td>
<td>11.3</td>
<td>0.19</td>
</tr>
<tr>
<td>Gender (% males)</td>
<td>45.4</td>
<td>46.1</td>
<td>0.018</td>
</tr>
<tr>
<td>Parental education level (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>71.2</td>
<td>46.3</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>High</td>
<td>28.8</td>
<td>53.7</td>
<td></td>
</tr>
<tr>
<td>BMI (mean, SD)</td>
<td>19.5 (3.7)</td>
<td>20.5 (3.8)</td>
<td>0.009</td>
</tr>
<tr>
<td>WC (mean, SD)</td>
<td>68.1 (9.6)</td>
<td>70.8 (9.8)</td>
<td>0.008</td>
</tr>
</tbody>
</table>

| Netherlands          |           |           |          |
| N                    | 75 (8.2)  | 844 (91.8) |          |
| Age (mean, SD)       | 11.9      | 11.7      | 0.055    |
| Gender (% males)     | 50.7      | 49.5      | 0.036    |
| Parental education level (%) |       |           |          |
| Low                  | 66.7      | 20.8      | 0.001    |
| High                 | 33.3      | 79.2      |          |
| BMI (mean, SD)       | 19.8 (3.8)| 18.3 (3.0)| <0.001   |
| WC (mean, SD)        | 66.3 (8.9)| 63.0 (7.3)| <0.001   |

*Student's t-test (age, BMI, weight) and Pearson Chi-Square (% males, % parental education)

Parental response was much lower in the Netherlands (44%) compared with Greece (81%). Logistic regression analyses showed that non-response by parents was associated with language spoken at home in both samples, and also with age and BMI in the Dutch sample. Parents of older (Dutch sample OR=0.60; CI=0.50-0.72), heavier children (Dutch sample OR= 0.85; CI=0.85-0.94) and non-natives (Greek
sample OR=0.40; CI=0.26-0.63) (Dutch sample OR=0.28; CI=0.15,0.54) were less likely to complete the parental questionnaire.

**Energy Balance-Related Behaviors (EBRBs)**

In the Greek sample sugared drink intake and sleep duration were significantly higher, and sports participation significantly lower among non-native children (Table 2). Regarding the Dutch sample, non-native children reported significantly higher breakfast skipping.

Taking into account the described results, those EBRBs showing significant differences between native and non-native children were selected to test their potential mediating effect on the significant associations between the ethnicity indicator and body composition indicators (e.g. sugared drinks, sports participation and sleeping habits in the Greek sample; skipping breakfast in the Dutch sample).

<table>
<thead>
<tr>
<th></th>
<th>Greece</th>
<th>Netherlands</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Non-native (n=108)</td>
<td>Native (n=974)</td>
</tr>
<tr>
<td>Sugared drinks (L/day)</td>
<td>0.514 ± 0.545</td>
<td>0.359 ± 0.326***</td>
</tr>
<tr>
<td>Skipped breakfast ≥ 1 week (%)</td>
<td>50</td>
<td>46.8</td>
</tr>
<tr>
<td>Active transport (min/day)</td>
<td>9.6 ± 7.7</td>
<td>8.8 ± 7.7</td>
</tr>
<tr>
<td>Sports participation (min/day)</td>
<td>14.8 ± 19.9^^^^</td>
<td>23.9 ± 20.7</td>
</tr>
<tr>
<td>Screen time (hours/day)</td>
<td>3.48 ± 1.49</td>
<td>3.23 ± 1.59</td>
</tr>
<tr>
<td>Sleeping habits (hours/day)</td>
<td>9.0 ± 1.1</td>
<td>8.7 ± 0.8**</td>
</tr>
<tr>
<td></td>
<td>Non-native (n=64)</td>
<td>Native (n=769)</td>
</tr>
<tr>
<td>Sugared drinks (L/day)</td>
<td>1.151 ± 1.094</td>
<td>0.993 ± 0.733</td>
</tr>
<tr>
<td>FUSkipped breakfast ≥ 1 week (%)</td>
<td>37.5</td>
<td>21.8**</td>
</tr>
<tr>
<td>Active transport (min/day)</td>
<td>12.4 ± 10.2</td>
<td>12.0 ± 9.3</td>
</tr>
<tr>
<td>Sports participation (min/day)</td>
<td>25.8 ± 21.1</td>
<td>30.1 ± 21.5</td>
</tr>
<tr>
<td>Screen time (hours/day)</td>
<td>3.83 ± 1.95</td>
<td>3.35 ± 1.80</td>
</tr>
<tr>
<td>Sleeping habits (hours/day)</td>
<td>9.3 ± 0.9</td>
<td>9.6 ± 0.7</td>
</tr>
</tbody>
</table>

*P<0.05; **P<0.01; ***P<0.001 native significantly lower than non-native, adjusted for age and gender
^P<0.05; ^^P<0.01; ^^^P<0.001 non-native significantly lower than native, adjusted for age and gender

**Step 1: ethnic background and body composition indicators (c-path)**

The results showed that language spoken at home was significantly associated with BMI and WC in Greek and Dutch samples, but in different directions: Greek native children had higher BMI and WC compared to non-natives (Table 3), while Dutch
native children showed lower BMI and WC (Table 4).

Step 2: Associations between ethnic background and EBRBs (a-path)
As described in tables 3 and 4, significant associations with language spoken at home were found for consumption of sugared drinks, sports participation, and sleep duration in the Greek sample, while significant associations were found for breakfast in the Dutch sample. Sugared drinks intake and sleep duration were lower in the native Greek group. The odds of having breakfast everyday were significantly higher in the native Dutch children.

Step 3: Associations between EBRBs and children’s body composition (path-b)
In the Greek sample consumption of sugared drinks and sleep duration were inversely associated with both BMI and WC. Sports participation only showed significant inverse association with WC and only in the model not adjusted for parental education. In the Dutch sample, having breakfast everyday was inversely associated with BMI and WC.

Step 4: Mediation effects (a*b)
Indirect effects are shown in the 4th column of tables 3 and 4. Mediation effects in the Greek sample were statistically significant for consumption of sugared drinks in both models (BMI and WC). The mediated proportions varied, with higher proportion for the BMI model (16.9%) compared to the WC model (13.8%). Mediation effect was also significant for sleep duration in the BMI model (16.2%). Sports participation had a suppressive effect on the relationship between language spoken at home and WC (-10.1%), due to the opposite directions of the direct and indirect associations, indicating an increase of the association between the predictor (language) and the outcome (WC). After adjusting for parental education, none of the variables showed significant mediation effect (table 3). Regarding the Dutch sample (table 4), breakfast significantly mediated the association between language spoken at home and BMI/WC (23.7% and 21.8% respectively).

Step 5: Direct association (path-c’)
As presented in tables 3 and 4, the direct significant associations between ethnicity and body composition indicators remained significant after the inclusion of the presumed mediators in the models.
Table 3. Regression coefficients (B) and 95% confidence intervals (95% CI) as results from the mediation analyses in the association between language spoken at home (non-native=0, native=1) and BMI (kg/m²) / WC (cm) in Greek sample.

| Mediator: | Total association (path c) B (95% CI) | Language effect on mediator (path a) B (95% CI) | Single mediator effect on BMI (path b) B (95% CI) | Indirect effect (a*b) B (95% CI) | Direct effect (path c') B (95%) | Mediated % (a*b/c) |
|-----------|---------------------------------------|-----------------------------------------------|-------------------------------------------------|--------------------------------|
| Sugared drinks (L/day) * (n=1081) | 1.04 (0.37 ; 1.72) | -0.15 (-0.28 ; -0.03) | -1.15 (-1.81 ; -0.49) | 0.176 (0.006 ; 0.347) | 0.87 (0.21 ; 1.52) | 16.9 |
| Sports (Min/day)* (n=1081) | 1.03 (0.36 ; 1.70) | 9.07 (5.58 ; 12.56) | 0.007 (-0.019 ; 0.004) | -0.067 (-0.174 ; 0.040) | 1.10 (0.41 ; 1.78) | - |
| Sleep (Hours/day)* (n=1078) | 1.04 (0.36 ; 1.71) | -0.30 (-0.52 ; -0.08) | -0.56 (-0.84 ; -0.29) | 0.169 (0.009 ; 0.329) | 0.87 (0.22 ; 1.52) | 16.2 |
| Sugared drinks (L/day) † (n=890) | 1.11 (0.12 ; 2.10) | -0.08 (-0.17 ; 0.00) | -1.13 (-2.02 ; -0.24) | 0.093 (0.003 ; 0.219) | 1.02 (0.05 ; 1.99) | - |
| Sports (Min/day) † (n=890) | 1.09 (0.11 ; 2.07) | 9.91 (5.53 ; 14.30) | -0.005 (-0.016 ; 0.007) | -0.049 (-0.163 ; 0.065) | 1.14 (0.16 ; 2.12) | - |
| Sleep (Hours/day) † (n=890) | 1.10 (0.12 ; 2.08) | -0.18 (-0.19 ; -0.03) | -0.49 (-0.81 ; -0.17) | 0.087 (-0.034 ; 0.207) | 1.01 (0.05 ; 1.98) | - |

| Mediator: | Total association (c) B (95% CI) | Language effect on mediator (path a) B (95% CI) | Single mediator effect on WC (path b) B (95% CI) | Indirect effect (a*b) B (95% CI) | Direct effect (path c') B (95%) | Mediated % (a*b/c) |
|-----------|--------------------------------|-----------------------------------------------|------------------------------------------------|--------------------------------|
| Sugared drinks (L/day) * (n=1081) | 2.83 (0.99 ; 4.67) | -0.15 (-0.28 ; -0.03) | -2.53 (-4.36 ; -0.71) | 0.390 (0.039 ; 0.740) | 2.44 (0.68 ; 4.19) | 13.8 |
| Sports (Min/day)* (n=1081) | 2.80 (0.97 ; 4.63) | 9.07 (5.58 ; 12.55) | -0.031 (-0.056 ; -0.007) | -0.285 (-0.544 ; -0.027) | 3.09 (1.26 ; 4.92) | -10.1 |
| Sleep duration (Hours/day)* (n=1078) | 2.81 (0.98 ; 4.65) | -0.30 (-0.52 ; -0.08) | -1.11 (-1.82 ; -0.40) | 0.331 (-0.024 ; 0.686) | 2.48 (0.67 ; 4.30) | - |
| Sugared drinks (L/day) † (n=890) | 2.78 (0.19 ; 5.37) | -0.08 (-0.17 ; 0.00) | -2.59 (-5.11 ; -0.07) | 0.213 (-0.104 ; 0.529) | 2.57 (0.06 ; 5.07) | - |
| Sports (Min/day) † (n=890) | 2.73 (0.16 ; 5.30) | 9.89 (5.50 ; 14.28) | -0.025 (-0.052 ; 0.002) | -0.247 (-0.524 ; 0.031) | 2.98 (0.44 ; 5.52) | - |
| Sleep duration (Hours/day) † (n=890) | 2.75 (0.18 ; 5.32) | -0.18 (-0.39 ; 0.03) | -0.89 (-1.70 ; -0.07) | 0.157 (-0.096 ; 0.411) | 2.59 (0.07 ; 5.12) | - |

*Models adjusted for age and gender  †Models adjusted for age, gender and parental education level. path a, b, c refer to the paths depicted in Figure 1. Statistically significant associations are shown in bold.

Ethnic background differences in children's body composition. 57
Table 4. Regression coefficients (B) and 95% confidence intervals (95% CI) as results from the mediation analyses in the association between language spoken at home (non-native=0, native=1) and BMI (kg/m²) / WC (cm) in Dutch sample.

<table>
<thead>
<tr>
<th>BMI</th>
<th>Total association (path c)</th>
<th>Language effect on mediator (path a)</th>
<th>Single mediator effect on BMI (path b)</th>
<th>Indirect effect (a*b)</th>
<th>Direct effect (path c')</th>
<th>Percentage mediated (a*b/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B (95% CI)</td>
<td>B (95% CI)</td>
<td>B (95% CI)</td>
<td>B (95% CI)</td>
<td>B (95% CI)</td>
<td></td>
</tr>
<tr>
<td>Mediator:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breakfast * (n=911)</td>
<td>-1.30 (-1.79 ; -0.81)</td>
<td>2.16 (1.30 ; 3.61)**</td>
<td>-0.67 (-0.99 ; -0.34)</td>
<td>-0.309 (-0.600 ; -0.018)</td>
<td>-0.99 (-1.48 ; -0.50)</td>
<td>23.7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>WC</th>
<th>Total association (path c)</th>
<th>Language effect on mediator (path a)</th>
<th>Single mediator effect on WC (path b)</th>
<th>Indirect effect (a*b)</th>
<th>Direct effect (path c')</th>
<th>Percentage mediated (a*b/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B (95% CI)</td>
<td>B (95% CI)</td>
<td>B (95% CI)</td>
<td>B (95% CI)</td>
<td>B (95% CI)</td>
<td></td>
</tr>
<tr>
<td>Mediator:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breakfast * (n=911)</td>
<td>-2.76 (-4.36 ; -1.17)</td>
<td>2.16 (1.30 ; 3.61)**</td>
<td>-1.30 (-2.15 ; -0.45)</td>
<td>-1.603 (-1.209 ; -0.094)</td>
<td>-2.16 (-3.69 ; -0.62)</td>
<td>21.8</td>
</tr>
</tbody>
</table>

*Models adjusted for age and gender

**Logistic regression coefficients

path a, b,c c’ refer to the paths depicted in Figure 1.

Statistically significant associations are shown in bold
**DISCUSSION**

The present study explored if specific EBRBs could explain differences in body composition according to ethnic background, in two countries where ethnic differences in overweight status were present. In the Netherlands non-native children were more likely and in Greece non-native children were less likely to be overweight than native children (25). Partial mediation in the associations between ethnic background and children's body composition was found only for consumption of sugared drink and sleep duration in the Greek sample, and breakfast in the Dutch sample. A suppression effect was found for sports in the Greek sample, indicating that the magnitude of the relationship between ethnicity and WC became larger after the inclusion of the mediator in the model. After adjusting the mediation models for parental education in the Greek sample, no mediation was found.

The results suggest that differences in children's body composition between Dutch native and non-native children may be partially due to the higher proportion of breakfast skipping in non-native children. This finding is consistent with previous studies in which skipping breakfast is associated with a less favorable body composition in both children and adolescents (34). Previous reports also showed higher percentages of breakfast skipping among non-native children (7, 16, 35) but did not assess mediation effects of breakfast skipping on the association between ethnicity and children’s body composition.

Unlike in the Netherlands, and most other reports on ethnic differences (7, 10, 16, 36), Greek native children had higher BMI and WC compared to non-natives. Greek native children have the highest BMIs and WCs in Europe (5), and prevalence of overweight and obesity in Greek children is amongst the highest of the world (37). Compared to a population that is amongst the most overweight in the world, it is very likely that children with other ethnic backgrounds have lower overweight rates. Furthermore, many immigrants in Greece are from the most deprived countries in Europe, e.g. Albania and Romania, which may also account for their somewhat lower rates of overweight and obesity compared to native Greek children. However, non-native children in Greece still had higher BMI and prevalence of overweight and obesity than children in most other countries in Europe, suggesting that Greece has certain specific obesogenic characteristics.
The mediation analyses indicate that differences regarding sugared drink consumption, sleep duration and sports participation partially explain the existing body composition differences according to ethnicity in Greece. In agreement with the literature (38-40), sleep duration was inversely associated with body composition indicators, and was also found to be shorter in native Greek children, partially explaining the higher BMI and WC in native Greeks. Also in agreement with previous studies, native children reported lower sugared drinks intake (12), but unexpectedly and in contrast with other studies (41, 42) sugared drinks consumption was inversely associated with body composition in this Greek sample. These results may reflect actual lower intake of sugared drinks in overweight children in this country – suggesting that other behaviors are of key importance in Greece, or a higher impact of underreporting in this group (43, 44).

A suppression effect was found for sports participation in the Greek sample. As expected, sports participation was inversely associated with WC, but native children reported higher sports participation, even though they presented higher WC values. It has to be kept in mind that the information regarding sports reflects the engagement in structured sports activities, and not total physical activity. It is possible that non-native children may be less likely to get involved in sports clubs, for example because of financial barriers, but do engage in more daily physical activities even achieving a total amount of energy expenditure higher than the native Greek children.

To our knowledge, this is one of the first studies exploring the pathways between ethnicity, several EBRBs of special relevance in school-aged children, and children’s body composition by formally applying mediation analysis. The proportion of the associations explained by the identified mediators was relatively low, and a direct association between ethnicity and body composition remained statistically significant. That the proportion mediated was relatively low is not surprising as we only included one mediator in the models and it is very likely that many other factors (not measured in the ENERGY-study) can explain the observed ethnic differences. Furthermore, with large sample sizes it is very hard to find complete mediation. Nevertheless, it indicates that other relevant mediators, e.g. other health behaviors, may be of additional importance. Therefore, future studies should take into account more EBRBs in order to better explain the ethnic differences in body composition.
The mediated effects became non-significant after adjusting for parental education in the Greek sample. This finding may reflect the close relationship between ethnicity and parental educational and suggests an important role of the later in the associations between ethnicity, EBRBs and children's body composition. However, the sample size was substantially smaller in the models including parental education, due to the fact that this was reported in the parent questionnaire, which unfortunately had a lower response rate and obviously reduced statistical power. Additionally, further logistic regression analyses showed that parents from non-native children were less likely to complete the parental questionnaire (Greek sample OR=0.40; CI=0.26-0.63). This might imply a bias in the results, probably leading to weaker associations due to less variation and may explain the non-significant findings after adjusting the models by parental education.

Using the present analyses, we were not able to completely explain ethnic differences in body composition by the included EBRBs. The unexplained differences may be a result of the interaction with other variables (e.g. socioeconomic determinants, cultural background, biological factors) that determine the existing ethnic differences in children's body composition. It is also noteworthy that the EBRBs found to be mediating the ethnic differences in body composition are different for each of the assessed countries. This finding reflects the differences between countries and the need for tailored overweight prevention interventions.

A number of limitations should be taken into account. First of all, the results presented are based on cross-sectional data, and thus no causality can be established. Second, data on dietary, physical activity and sedentary behaviors were assessed by self-reports, and may be biased. Nevertheless, the measures showed good test-retest reliability and construct validity (26, 27). Additionally, the differences in response rates at school level were important, and may have an impact on the external validity of the findings. The response rates among schools and parents were lower in the Netherlands, underlining experiences with other Dutch school-based research programs over the last years. Missing data analysis revealed that parents of older and heavier children in the Dutch samples and non-native children in both samples were less likely to complete the parental questionnaire. Therefore, the results including adjustment for parental education should be interpreted carefully.

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Strengths of the current study include the standardized data collection protocol across the different countries and the measured weight, height and WC data along with the inclusion of behaviors that have been widely associated with overweight and obesity in children and adolescents.

CONCLUSION

Ethnic differences in children’s body composition were partially mediated by differences in breakfast skipping in the Netherlands and consumption of sugared drinks, sports participation and sleep duration in Greece. More studies are needed to disentangle which variables are able to further explain the ethnic differences in children’s body composition.

ACKNOWLEDGEMENTS

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References
41. de Ruyter JC, Olthof MR, Seidell JC, Katan MB. A trial of sugar-free or sugar-sweetened beverages and body weight in children. The New England journal of medicine


ASSOCIATIONS BETWEEN PARENTAL EDUCATION AND CHILDREN’S ENERGY BALANCE-RELATED BEHAVIOURS
CLUSTERING OF ENERGY BALANCE-RELATED BEHAVIOURS AND PARENTAL EDUCATION IN EUROPEAN CHILDREN: THE ENERGY-PROJECT

Juan Miguel Fernández Alvira, Ilse De Bourdeaudhuij, Amika Singh, Frøydis N Vik, Yannis Manios, Eva Kovacs, Nataša Jan, Johannes Brug, Luis A Moreno

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ABSTRACT

Background: Recent research and literature reviews show that, among schoolchildren, some specific energy balance-related behaviours (EBRBs) are relevant for overweight and obesity prevention. It is also well known that the prevalence of overweight and obesity is considerably higher among schoolchildren from lower socio-economic backgrounds. This study examines whether sugared drinks intake, physical activity, screen time and usual sleep duration cluster in reliable and meaningful ways among European children, and whether the identified clusters could be characterized by parental education.

Methods: The cross-sectional study comprised a total of 5284 children (46% male), from seven European countries participating in the ENERGY-project (“EuropeaN Energy balance Research to prevent excessive weight Gain among Youth”). Information on sugared drinks intake, physical activity, screen time and usual sleep duration was obtained using validated self-report questionnaires. Based on these behaviours, gender-specific cluster analysis was performed. Associations with parental education were identified using chi-square tests and odds ratios.

Results: Five meaningful and stable clusters were found for both genders. The cluster with high physical activity level showed the highest proportion of participants with highly educated parents, while clusters with high sugared drinks consumption, high screen time and low sleep duration were more prevalent in the group with lower educated parents. Odds ratio showed that children with lower educated parents were less likely to be allocated in the active cluster and more likely to be allocated in the low activity/sedentary pattern cluster.

Conclusions: Children with lower educated parents seemed to be more likely to present unhealthier EBRBs clustering, mainly characterized by their self-reported time spent on physical activity and screen viewing. Therefore, special focus should be given to lower educated parents and their children in order to develop effective primary prevention strategies.
BACKGROUND

 Despite a levelling-off of obesity prevalence in some countries in the last years, childhood obesity still shows an unacceptable high prevalence(1), with secular trends to higher fat mass and more central fat distribution, even in non-obese children and adolescents(2). Moreover, evidence shows that overweight and obesity track from childhood to adulthood(3, 4).

 Even if genetic factors may influence the susceptibility of some individuals to gain weight(5), there is a general consensus that lifestyle factors are driving the obesity epidemic(6). Recent research and literature reviews show that, among schoolchildren, some specific energy balance-related behaviours (EBRBs) are at least associated with overweight and obesity prevalence and may be important for obesity prevention(7-11). These behaviours comprise, among others, the intake of sugared drinks, screen viewing behaviour (TV viewing and sedentary computer activities) and regular physical activities, like active commuting to school, participation in sports and recreational physical activity. In addition, recent evidence suggests that sleeping habits may also be relevant for energy balance(12, 13).

 It is also well known that the prevalence of overweight and obesity is considerably higher among youth from lower socio-economic backgrounds(14-18). Parental education has been associated with several EBRBs in children and adolescents, showing higher sugared drinks consumption (19, 20), lower physical activity levels (21) and higher sedentary behaviour levels (22) among children with lower educated parents, while mixed results have been found regarding the association between parental education and sleep duration(23-25). The majority of the literature focused on each of these EBRBs separately, sometimes also including reports on its socio-demographic correlates(22, 26-28). However, there is little information about the co-occurrence of these EBRBs and the association with socio-demographic factors. Specifically cross-European studies providing insight about EBRBs clustering and their socio-demographic correlates are lacking.

 EBRBs clustering refers to a combination of behaviours that is more prevalent than expected based on the prevalence of the separate behaviours(29). The potential synergy between EBRBs should be taken into account in obesity prevention interventions, as the combination of several unhealthy behaviours could lead to a
multiplication of the risk. Furthermore, a better insight in the clustering of multiple behaviours in relation to socio-demographic correlates could help to identify subgroups at increased risk in developing overweight and obesity. Since childhood and adolescence are critical periods during lifetime in adopting health behaviours, the study of multiple health indices should be a public health priority.

In addition to the recently published report on EBRBs differences by Brug et al.(26), in which children of lower educated parents reported less favourable intakes regarding soft drinks and fruit juice, higher total screen time and lower participation in sports than those from higher educated parents, cluster analysis was applied in this study. It allows to specifically detecting co-occurrence of risky EBRBs levels. Additionally, it is possible to evaluate if these combinations of risky EBRBs are more prevalent in some groups characterized by parental education level.

More precisely, the first aim of the analysis was to examine whether EBRBs assessed in the cross-European study (i.e. sugared drinks intake, physical activity, screen time and usual sleep duration) cluster in a reliable and meaningful way among European children, characterized by healthy or unhealthy EBRBs combinations. The second aim was to investigate whether these identified clusters could be characterized by parental education, taking into account other important correlates, like gender and Body Mass Index (BMI).

**METHODS**

**Study population**
Data were obtained from the cross sectional study of the “EuropeaN Energy balance Research to prevent excessive weight Gain among Youth” (ENERGY) project. This cross-sectional study was carried out between March and July 2010 in Belgium, Greece, Hungary, the Netherlands, Norway, Slovenia and Spain, among pupils in the final years of primary education (aged 10-12 years). The aim of the survey was to provide up to date information on the prevalence of overweight and obesity, on the most important EBRBs and their social, cognitive and school environmental determinants. Based on previous cross-European studies, a minimum sample of 1000 schoolchildren per country and one parent/caretaker for each child were aimed for
The schools were randomly selected concerning the degree of urbanization of the different provinces and the socioeconomic status (SES) of the different areas within the selected provinces. Samples were national representative in Greece, Hungary, the Netherlands and Slovenia. In Spain, schools of the region of Aragón were selected; Belgium selected schools from Flanders and Norway selected schools from the southern regions of the country.

A description of the rationale, design, procedures and methodology of the ENERGY school-based survey is published elsewhere. A first paper on prevalence of overweight, obesity and engagement in different EBRBs as well as differences in these prevalence according to parental education, has been published elsewhere. The studies were approved by the corresponding local ethics committees. School recruitment letters were sent to the headmasters or principals of the sampled schools, and after school’s agreement, parents were asked for written consent for their child’s and own voluntary participation.

Data collection
Information on children’s EBRBs and parental education was obtained using self-reported questionnaires. Anthropometric measures were performed by trained researchers/research assistants following a according to standardized protocols. The children completed questionnaires and anthropometric measurements were performed during school time.

Energy balance-related behaviours
Children provided data on dietary, physical activity and screen viewing behaviours via the child questionnaire, while sleep duration was reported by the parents. Both children and parental questionnaires showed a good test-retest reliability and moderate to good construct validity for the large majority of items.

Dietary behaviours
Intakes of soft drinks and fruit juices were assessed with two food frequency questions. Children were asked how many days per week they drank the beverage, answering on a seven-point scale from never to more than once every day. Afterwards they were asked to indicate how much they drank by ticking the number of glasses or small bottles (e.g. 250 ml), cans (i.e. 330 ml) and large bottles (i.e. 500 ml) for soft drinks, or glasses/small cartons (i.e. 250 ml) and regular cartons (330
ml) for fruit juices. The questionnaire included pictures of the serving sizes. Mean intake in millilitre (ml) per day was calculated from these two questions. In addition, children were asked to fill in how much of the beverages they had consumed on the day before, following the same classification. For the purposes of this analysis, ml/day of sugared drinks (soft drinks + fruit juices) were taken into account.

**Physical activity behaviours**
Active transportation to school was assessed by two questions about how many days per week the child cycled and/or walked to school, ranging from never to 5 days/week, and two questions on the duration of biking or walking to school, with 4 answer categories ranging from 1-5 minutes to more than 15 minutes. Total active transportation time per week was calculated by adding up total bike and walk times and multiplying the number of days with the mean time of the answering category times 2. Organized sports participation was assessed with specific questions about how many hours per week children participated in one or two sports. Based on the answers, average time of sports participation per week was calculated. Finally, min/day of total physical activity (active transportation + sports participation) were included in the analysis.

**Sedentary behaviours**
Screen time (i.e. TV and computer time) was assessed separately for weekdays and weekend days by two questions about time spent watching TV (including video and DVD) and computer activities. Mean TV, computer and total screen time per day were calculated. For the analyses, total min/day of screen time (TV watching plus computer use) were taken into account. 
*Sleep duration.* Child's sleep habits reported by the parents included the number of hours the child sleeps per night on average, reported separately for weekdays and weekend days. For the purpose of this paper, only weekdays (hours/day of sleep duration) were taken into account as sleep during weekdays is likely to be more representative of usual sleep duration, due to the more regular bed- and get-up routine(13).

**Parental education**
Parents were asked to report their own level of education, as well as the level of education of the other parent/caregiver. The possible answers were: a) less than 7 years b) 7-9 years c) 10-11 years d) 12-13 years e) 14 years or more. These years
take into account the different educational levels since preschool. Thus, the category “c” in this international dataset approximately distinguishes families with a caregiver who has completed medium or higher vocational, college or university training from other families. After preliminary analyses of the distribution of the variable, it was concluded that to recategorize into low, medium and high parental education level was not possible due to the small sample size included in the low category. Both scores (maternal and paternal education levels) were combined, and dichotomized into low (0, both parent/caregivers with fewer than 14 years of education) and high (at least one parent/caregiver with 14 or more years of education).

**Anthropometric measurements**

Body height and weight were measured by trained research assistants. The children were measured in light clothing without shoes. Body height was measured with Seca Leicester Portable stadiometer (to the nearest 0.1 cm). Weight was measured with a calibrated electronic scale SECA 861 (to the nearest 0.1 kg). Two readings of each measurement were performed. When readings differed more than 1 %, a third reading was taken. Body Mass Index (BMI) and overweight status (overweight, obesity) based on the International Obesity Task Force criteria (IOTF)(34) were calculated.

**Data analysis**

To identify clusters with similar dietary, physical activity and sedentary habits, a combination of hierarchical and non-hierarchical clustering analysis was used(35). Gender-specific cluster analyses were performed, due to the significant influence of gender in the EBRBs means (Table 2). Z-scores of all variables were calculated to standardize the data set before clustering. This prevents variables measured in larger ranges from contributing to the distance largely than variables with smaller ranges. Univariate and multivariate outliers (more than 3 standard deviations) were removed. In a first step, hierarchical cluster analysis was applied using Ward's method, based on squared Euclidian distances(36). At this stage, comparison of several possible cluster solutions was performed. Using the resulting centroids, a non-hierarchical k-means cluster analysis was performed, in order to further fine-tune the preliminary hierarchical cluster solution. ANOVA tests and post hoc Bonferroni tests were used to investigate the differences between each cluster on all indices.

Clustering of energy balance-related behaviors and parental education 75
Chi-square tests were performed to investigate the differences on cluster distribution by country, BMI category, and parental education level. Odds ratios for being allocated in one specific cluster by parental education level were also calculated (adjusting for age, country and BMI z-scores). All statistical analyses were performed using the Predictive Analytic Software (PASW) version 18.0 (SPSS inc., Chicago, IL, USA).

RESULTS

Table 1 describes the characteristics of the participating children (n=5284). The mean age of children was 11.6 (0.73) years, 54.3% girls. As defined by at least one parent/caregiver with at least 14 years of education, 67.5% of the participants were included in the high parental education group. Across the countries, 20.4 % and 4.8 % of children were overweight (including obese) and obese respectively. The sample size varied between countries, mostly because of differences in parental response rates.

Table 1 - Characteristics of the total sample

<table>
<thead>
<tr>
<th></th>
<th>Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>11.6 (0.73)</td>
</tr>
<tr>
<td>Gender</td>
<td>N (%)</td>
</tr>
<tr>
<td>Boys</td>
<td>2413 (45.7)</td>
</tr>
<tr>
<td>Girls</td>
<td>2871 (54.3)</td>
</tr>
<tr>
<td>BMI status</td>
<td></td>
</tr>
<tr>
<td>Normal weight</td>
<td>3930 (74.4)</td>
</tr>
<tr>
<td>Overweight</td>
<td>1030 (20.4)</td>
</tr>
<tr>
<td>Obese</td>
<td>248 (4.8)</td>
</tr>
<tr>
<td>Parental education level</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>1686 (32.5)</td>
</tr>
<tr>
<td>High</td>
<td>3497 (67.5)</td>
</tr>
<tr>
<td>Country</td>
<td></td>
</tr>
<tr>
<td>Belgium</td>
<td>654 (12.4)</td>
</tr>
<tr>
<td>Greece</td>
<td>958 (18.1)</td>
</tr>
<tr>
<td>Hungary</td>
<td>811 (15.3)</td>
</tr>
<tr>
<td>the Netherlands</td>
<td>362 (6.9)</td>
</tr>
<tr>
<td>Norway</td>
<td>750 (14.2)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>856 (16.2)</td>
</tr>
<tr>
<td>Spain</td>
<td>893 (16.9)</td>
</tr>
</tbody>
</table>
Based on the four EBRBs indices, the five-cluster solutions were found to be adequate and meaningful regarding the different patterns for both genders, but the clusters differed somewhat between boys and girls. The reliability and stability of the created five-cluster solutions were examined by randomly dividing the samples into two subsamples, in which the same clustering procedure was repeated. Kappa degrees of concordance in cluster membership were calculated by comparing membership of both subsamples separately with these of the total gender-specific sample, showing excellent agreement for both girls (k=0.97 and 0.98 for the first and second subsample respectively), and boys (k=0.98 and 0.97 for the two subsamples).

Table 2 - Gender-specific means (SD) of energy balance related behaviors in seven European countries participating in the ENERGY study.

<table>
<thead>
<tr>
<th>Country</th>
<th>Sugared drinks (ml/day)</th>
<th>Physical activity (min/day)</th>
<th>Screen time (min/day)</th>
<th>Sleep duration (hours/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>boys</td>
<td>girls</td>
<td>boys</td>
<td>girls</td>
</tr>
<tr>
<td>Belgium</td>
<td>654</td>
<td>639(32.1)</td>
<td>597(28.1)</td>
<td>37(1.3)</td>
</tr>
<tr>
<td>Greece</td>
<td>958</td>
<td>409(17.9)†</td>
<td>329(12.7)</td>
<td>33(1.1)†</td>
</tr>
<tr>
<td>Hungary</td>
<td>811</td>
<td>843(35.9)†</td>
<td>735(29.0)</td>
<td>46(1.5)†</td>
</tr>
<tr>
<td>the Netherlands</td>
<td>362</td>
<td>844(47.7)</td>
<td>799(38.1)</td>
<td>41(1.6)†</td>
</tr>
<tr>
<td>Norway</td>
<td>750</td>
<td>482(23.6)†</td>
<td>323(16.1)</td>
<td>57(1.4)†</td>
</tr>
<tr>
<td>Slovenia</td>
<td>856</td>
<td>740(32.3)†</td>
<td>531(23.6)</td>
<td>48(1.3)†</td>
</tr>
<tr>
<td>Spain</td>
<td>893</td>
<td>465(21.5)†</td>
<td>331(16.1)</td>
<td>44(1.2)†</td>
</tr>
<tr>
<td>Total</td>
<td>5284</td>
<td>606(11.4)†</td>
<td>490(9.1)</td>
<td>44(0.5)†</td>
</tr>
</tbody>
</table>

† Significant differences between gender p<0.05

**Description of the clusters**

Four of the five clusters received the same labels for boys and girls due to the similar characteristics for both sexes, although cluster mean values differed. These four clusters were labelled as active pattern; long sleepers inactive pattern; sedentary sugared drinks consumers; short sleepers inactive pattern. The fifth cluster differed between girls and boys and was labelled as “low activity pattern” for girls and as “sedentary pattern” for boys. Distinguishing characteristics of each cluster are indicated by high or low z-scores. Final cluster centres and labels are presented in figures 1 and 2. Row mean values (mean ± standard deviation) are presented in Table 3.
Figure 1 - Standard deviation scores of clusters on EBRBs for girls

Figure 2 - Standard deviation scores of clusters on EBRBs for boys
The active pattern was characterized by z-scores above 0 for physical activity and z-scores below 0 for sugared drinks consumption and screen time. The physical activity score was significantly higher in the boys’ cluster (z-score = 1.41) compared to the girls’ cluster (z-score = 1.13). Long sleepers inactive pattern cluster was characterized by high values on sleep duration (z-scores >1.23) and low scores on the rest of behaviours. Sedentary sugared drinks consumers group presented high values for sugared drinks consumption and for screen time. However, the sugared drinks score was much higher in the boys’ cluster (z-score = 1.82) compared to the girls’ cluster (z-score = 0.50), while the screen time score was higher in the girls’ cluster (z-score = 1.20) compared to the boys’ cluster (z-score = 0.62).

Table 3 - Means and Standard Errors for four energy balance related behaviours (EBRB) in four clusters of behavioural patterns, and results of analyses of variance and Bonferroni post hoc tests to test for significant differences in the mean values for these behaviours between the different clusters.
The short sleepers inactive pattern cluster showed very low values for sleep duration and low values on the rest of behaviours. Girls included in this cluster presented lower sleep duration values (z-score = -1.34) compared to boys (z-score = -0.60). Low activity pattern cluster in girls was characterized by low values on all the behaviours, while the sedentary pattern cluster in boys presented a very high score on screen time (z-score = 1.65) and almost average values for the rest of the behaviours.

**Cluster group characteristics**

The associations between the five clusters and the socio-demographic variables (country, BMI and parental education level) are presented in table 4. Significant chi-squares were found for country, BMI and parental education level. Country specific representation varied in the different clusters. The active pattern cluster comprised significantly more Norwegian and Slovenian boys and girls; the long sleepers inactive cluster included the highest proportion of Belgian participants, while the short sleepers inactive pattern included the highest proportion of Greek boys and girls; the sedentary sugared drinks consumers were more prevalent in the Hungarian sample and, finally, the fifth cluster was mainly represented by Spanish and Greek girls (low activity pattern), and by Greek and Spanish boys (sedentary pattern).

The long sleepers inactive pattern had the lowest proportions of overweight and obese girls (12%; 2%), while the active pattern had the lowest proportions of overweight and obese boys (16%; 3%). The short sleepers inactive pattern comprised the highest proportion of overweight and obese girls (22%; 9%) as well as boys (28%; 7%).

The active pattern and long sleepers inactive pattern clusters showed the highest proportion of participants with parental (76% and 72% for girls; 75% and 74 % for boys) education level. The sedentary sugared drinks consumers cluster and the short sleepers inactive pattern cluster comprised the highest proportions of girls with lower parental (42% and 42%) educational level, while the sedentary pattern and the sedentary sugared drinks consumers clusters presented the highest proportion of boys with lower parental (39% and 39%) educational level.
Table 4 - Percentage of girls and boys in each of four clusters based on four energy balance-related behaviours cluster, according to socio-demographic factors and results of Chi Square tests

### GIRLS

<table>
<thead>
<tr>
<th>Country</th>
<th>N</th>
<th>Active pattern (%)</th>
<th>Long sleepers inactive pattern (%)</th>
<th>Sedentary sugared drinks consumers (%)</th>
<th>Short sleepers inactive pattern (%)</th>
<th>Low activity (%)</th>
<th>Chi-square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>356</td>
<td>8.6</td>
<td>27.5</td>
<td>15.1</td>
<td>3</td>
<td>7.7</td>
<td>923.297*</td>
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<tr>
<td>Greece</td>
<td>532</td>
<td>7.8</td>
<td>8.3</td>
<td>11</td>
<td>46.5</td>
<td>21.1</td>
<td></td>
</tr>
<tr>
<td>Hungary</td>
<td>458</td>
<td>16.1</td>
<td>7.2</td>
<td>28.7</td>
<td>17</td>
<td>14.8</td>
<td></td>
</tr>
<tr>
<td>the Netherlands</td>
<td>190</td>
<td>3.3</td>
<td>15.6</td>
<td>8.5</td>
<td>1.5</td>
<td>4.3</td>
<td></td>
</tr>
<tr>
<td>Norway</td>
<td>404</td>
<td>28.9</td>
<td>9.3</td>
<td>7.6</td>
<td>8.3</td>
<td>13.1</td>
<td></td>
</tr>
<tr>
<td>Slovenia</td>
<td>463</td>
<td>24.2</td>
<td>10.4</td>
<td>18.6</td>
<td>13</td>
<td>14.5</td>
<td></td>
</tr>
<tr>
<td>Spain</td>
<td>468</td>
<td>11.2</td>
<td>21.8</td>
<td>10.6</td>
<td>10.6</td>
<td>24.6</td>
<td></td>
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<tr>
<td>Total</td>
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<td></td>
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</table>

### BMI

<table>
<thead>
<tr>
<th>Parental education</th>
<th>N</th>
<th>Active pattern (%)</th>
<th>Long sleepers inactive pattern (%)</th>
<th>Sedentary sugared drinks consumers (%)</th>
<th>Short sleepers inactive pattern (%)</th>
<th>Sedentary pattern (%)</th>
<th>Chi-square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal weight</td>
<td>2198</td>
<td>82.4</td>
<td>85.7</td>
<td>74.9</td>
<td>68.8</td>
<td>74.6</td>
<td>78.338*</td>
</tr>
<tr>
<td>Overweight</td>
<td>509</td>
<td>15.5</td>
<td>12</td>
<td>19.1</td>
<td>22.4</td>
<td>21.7</td>
<td></td>
</tr>
<tr>
<td>Parental education</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>122</td>
<td>2.1</td>
<td>2.3</td>
<td>5.9</td>
<td>8.7</td>
<td>3.7</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>1713</td>
<td>75.6</td>
<td>71.8</td>
<td>57.6</td>
<td>57.6</td>
<td>70</td>
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</tr>
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</table>

### BOYS

<table>
<thead>
<tr>
<th>Country</th>
<th>N</th>
<th>Active pattern (%)</th>
<th>Long sleepers inactive pattern (%)</th>
<th>Sedentary sugared drinks consumers (%)</th>
<th>Short sleepers inactive pattern (%)</th>
<th>Sedentary pattern (%)</th>
<th>Chi-square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>298</td>
<td>5.9</td>
<td>30.5</td>
<td>13.8</td>
<td>7.2</td>
<td>8.2</td>
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</tr>
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<td>7.6</td>
<td>7.1</td>
<td>6.5</td>
<td>5</td>
<td>31.3</td>
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</tr>
<tr>
<td>Hungary</td>
<td>353</td>
<td>16.5</td>
<td>6.5</td>
<td>28.8</td>
<td>12.9</td>
<td>16.7</td>
<td></td>
</tr>
<tr>
<td>the Netherlands</td>
<td>172</td>
<td>3.7</td>
<td>12.9</td>
<td>13.3</td>
<td>4.1</td>
<td>6.7</td>
<td></td>
</tr>
<tr>
<td>Norway</td>
<td>346</td>
<td>28.9</td>
<td>10.2</td>
<td>7.1</td>
<td>9.8</td>
<td>12.5</td>
<td></td>
</tr>
<tr>
<td>Slovenia</td>
<td>393</td>
<td>19.6</td>
<td>11.7</td>
<td>24.6</td>
<td>15.4</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Spain</td>
<td>425</td>
<td>17.8</td>
<td>21.1</td>
<td>7.5</td>
<td>18.7</td>
<td>17.2</td>
<td></td>
</tr>
<tr>
<td>Total</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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</table>

### BMI

<table>
<thead>
<tr>
<th>Parental education</th>
<th>N</th>
<th>Active pattern (%)</th>
<th>Long sleepers inactive pattern (%)</th>
<th>Sedentary sugared drinks consumers (%)</th>
<th>Short sleepers inactive pattern (%)</th>
<th>Sedentary pattern (%)</th>
<th>Chi-square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal weight</td>
<td>1732</td>
<td>80.9</td>
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<td>74.8</td>
<td>64.9</td>
<td>68.6</td>
<td>55.800*</td>
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<tr>
<td>Overweight</td>
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<td>16.4</td>
<td>17.3</td>
<td>20.1</td>
<td>27.7</td>
<td>24.8</td>
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<tr>
<td>Obese</td>
<td>126</td>
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<td>4</td>
<td>5.1</td>
<td>7.4</td>
<td>6.6</td>
<td></td>
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<tr>
<td>Parental education</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>665</td>
<td>25.3</td>
<td>26</td>
<td>39.2</td>
<td>32.7</td>
<td>38.8</td>
<td>29.133*</td>
</tr>
<tr>
<td>High</td>
<td>1461</td>
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<td>74</td>
<td>60.8</td>
<td>67.3</td>
<td>61.2</td>
<td></td>
</tr>
</tbody>
</table>

* P<0.001

Clustering of energy balance-related behaviors and parental education  81
After exploring the associations of gender, country and BMI with the cluster distribution, odds ratios were calculated for being allocated in a specific cluster by parental education level, adjusted for the other socio-demographic characteristics (table 5). The results show that girls (OR: 0.58; 95% CI: 0.46-0.74) and boys (OR: 0.69; 95% CI: 0.54-0.87) with lower educated parents were significantly less likely to be allocated in the active pattern. Girls (OR: 0.78; 95% CI: 0.65-0.94) and boys (OR: 0.69; 95% CI: 0.55-0.87) with lower educated parents were also less likely to be allocated in the short sleepers inactive pattern. On the contrary, girls (OR: 1.93; 95% CI: 1.40-2.66) and boys (OR: 1.45; 95% CI: 1.09-1.92) with lower educated parents were more likely to be allocated in the low activity/sedentary pattern. Finally, girls with lower educated parents were more likely to be allocated in the long sleepers inactive pattern (OR: 1.37; CI: 1.07-1.76) and in the sedentary sugared drinks consumers pattern (OR: 1.35; 95% CI: 1.08-1.70).

Table 5 - Odds ratios (OR) and 95% confidence intervals (CI) for being allocated in a specific cluster by parental education levels (Ref: High; adjusted by country, BMI z-scores and age) for girls and boys

<table>
<thead>
<tr>
<th>Girls (n=3025)</th>
<th>Low parental education</th>
<th>OR</th>
<th>CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active pattern</td>
<td></td>
<td>0.58†</td>
<td>0.46-0.74</td>
</tr>
<tr>
<td>Long sleepers inactive pattern</td>
<td></td>
<td>1.37*</td>
<td>1.07-1.76</td>
</tr>
<tr>
<td>Sedentary sugared drinks consumers</td>
<td></td>
<td>1.35*</td>
<td>1.08-1.70</td>
</tr>
<tr>
<td>Short sleepers inactive pattern</td>
<td></td>
<td>0.78*</td>
<td>0.65-0.94</td>
</tr>
<tr>
<td>Low activity pattern</td>
<td></td>
<td>1.93†</td>
<td>1.40-2.66</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Boys (n=2604)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Active pattern</td>
<td></td>
<td>0.69†</td>
<td>0.54-0.87</td>
</tr>
<tr>
<td>Long sleepers inactive pattern</td>
<td></td>
<td>1.24</td>
<td>0.99-1.56</td>
</tr>
<tr>
<td>Sedentary sugared drinks consumers</td>
<td></td>
<td>0.96</td>
<td>0.74-1.27</td>
</tr>
<tr>
<td>Short sleepers inactive pattern</td>
<td></td>
<td>0.69*</td>
<td>0.55-0.87</td>
</tr>
<tr>
<td>Sedentary pattern</td>
<td></td>
<td>1.45*</td>
<td>1.09-1.92</td>
</tr>
</tbody>
</table>

*p<0.05; †p<0.01
DISCUSSION

The first goal of this paper was to explore the existence of clusters of EBRBs in a large sample of school-age children across Europe. Five reliable EBRBs clusters showing good stability were identified for both boys and girls. Meaningful clusters were found while correlations between the EBRBs were low, showing that low correlations do not exclude co-occurrence of health-related behavioural indicators within certain groups. One of the major findings is that none of the clusters showed marked healthy or unhealthy trends for all the included EBRBs. This fact implies that health-related behaviours do not always discriminate in the same direction. Children with specific healthy habits are not necessarily predisposed to be involved in other specific healthy behaviours. Similar results were found in previously published studies (37, 38). Cluster prevalence was not equal for each subgroup; the most prevalent were patterns characterized by low physical activity.

The results pertaining to the second goal – the characterization of the cluster solutions by parental education level and correlates – revealed that the cluster distribution was significantly different according to parental education level. It was clear that parental education was relevant for children’s EBRBs patterns. Children from higher educated parents were more likely to be allocated in the active pattern cluster, while low activity/sedentary pattern and sedentary sugared drink consumers were more prevalent among children from lower educated parents. It is noteworthy that low activity/sedentary pattern and sedentary sugared drink consumers pattern combined unhealthy levels in more than one of the assessed EBRB. These results suggest that children from lower educated parents are not only more likely to engage in less healthy behaviours (39, 40), but also more prevalent in clusters combining more unhealthy lifestyles. These results suggest the need to specifically address the relevance of physical activity and sedentary behaviours in obesity prevention strategies focusing on lower educated parents and their children.

The results show that children (both boys and girls) in the active cluster had below average screen time levels, and those children in the sedentary clusters (sedentary sugared drinks consumers for girls, sedentary pattern for boys) had also below average physical activity levels. This may suggest that there is some displacement between sedentary behaviour and physical activity, and vice versa, although earlier studies suggest being careful with this displacement theory, as this displacement mechanism seems not to be universal across countries (41, 42).
The cluster solutions included two groups mainly characterized by their sleep duration scores (Long sleepers inactive pattern and short sleepers inactive pattern). Even if these groups showed an association with parental education, sleep did appear to differ in a stronger way according to country with more long sleepers in northern countries and more short sleepers in southern-east countries, in line with previous studies (13). This distribution seems to reflect an important country-specific cultural influence on sleep duration in children.

The cluster solutions showed large gender differences. These differences were reflected not only in the clustering itself (with a gender specific cluster, namely the low activity/sedentary pattern cluster) but also in the behavioural levels in the rest of the clusters. One of the main differences was found for sugared drinks intake, much higher for boys compared to girls, in agreement with previous literature (43, 44).

Additionally, cluster solutions were also characterized by BMI. The short sleepers inactive pattern was the cluster with the highest proportion of overweight and obese boys and girls. In general, previous research showed that short sleep duration is associated with higher risk of childhood obesity (26, 45). However, our findings should be interpreted with caution, taking into account the disproportionate country-specific representation in the short sleepers inactive cluster (i.e. Greek sample).

Finally, it has to be kept in mind that this study is subject to some limitations. First, this concerns a cross-sectional study providing evidence for associations but not causation. Further, data on dietary, physical activity and sedentary behaviours were based on self-reports, and thus possibly biased. However, the measures showed good test-retest reliability and construct validity (33). Additionally, for some behaviours both 24-h recall and frequency questions were included, showing similar results. When considering sedentary behaviours it is also important to note that some sedentary activities, like reading or studying were not included in the present study. Is therefore possible that questionnaires did not reflect the real, total time spent in sedentary behaviours.

Strengths of the present study include the large multinational sample from different regions across Europe and the standardized data collection protocol across the different countries. The use of cluster analysis for the assessment of EBRBs in
relation with socio-demographic variables allowed us to reflect a more ecological view of the actual children’s behaviours and their socio demographic correlates. The described clusters in the present analysis showed a good stability and could therefore be seen as representative clusters for European children. It could be interesting for future research to examine the effectiveness of tailored obesity prevention strategies focusing on the most prevalent combinations of unhealthy EBRBs, with special attention to subgroups at higher risk, like children of lower educated parents.

**CONCLUSIONS**

The obtained stable cluster solutions allowed us to classify children according to several health behaviours that are associated with risk for overweight and obesity. None of the clusters showed marked healthy or unhealthy trends for all the included EBRBs. However, parental education was associated with the odds for being allocated in specific clusters, mainly characterized by their physical activity and screen time scores that combined more than one unhealthy EBRB. Children with lower educated parents seemed to be more likely to present unhealthier EBRBs clustering compared to those with highly educated parents. Therefore, special attention should be given to lower educated parents and their children when developing childhood obesity prevention strategies focusing on clusters of unhealthy lifestyles.

**ACKNOWLEDGEMENTS**

The ENERGY-project is funded by the Seventh Framework Programme (CORDIS FP7) of the European Commission, HEALTH (FP7-HEALTH-2007-B). The content of this article reflects only the authors’ views and the European Community is not liable for any use that may be made of the information contained therein.
References

17. te Velde SJ, De Bourdeaudhuij I, Thorsdottir I, Rasmussen M, Hagstromer M,


ASSOCIATIONS OF PARENTAL EDUCATION AND PARENTAL PHYSICAL ACTIVITY (PA) WITH CHILDREN’S PA: THE ENERGY CROSS-SECTIONAL STUDY

David Jiménez-Pavón, Juan Miguel Fernández-Alvira, Saskia te Velde, Johannes Brug, Elling Bere, Nataša Jan, Eva Kovacs, Odysseas Androutsos, Yannis Manios Ilse De Bourdeaudhuij, Luis A Moreno

ABSTRACT

Objective: The present study investigated the independent associations of parental education and physical activity (PA) with children’s PA across Europe.

Methods: A total of 7214 children (10-12 years) were recruited from a school-based cross sectional survey during 2010 in seven European countries. Weight and height were measured. Parental educational level (PEL) and parents’ and children’s PA were collected using self-reported questionnaires. Multiple linear regression models were used; comparing children’s PA with PEL and PA levels.

Results: PEL was directly associated with children’s PA in girls in Greece and Spain (all P<0.01) and boys’ PA in Norway (all P<0.05). PEL was directly associated with PA in boys in Hungary (P<0.05). In overall, parental PA was directly associated with children’s PA in more than half of the countries involved (all P<0.05).

Conclusion: Our observations suggest that PEL and parental modelling of PA are two independent factors from the home environment associated with children’s PA, but the relationships were gender and country-specific. Further studies should be focused on intervention strategies for increasing children’s PA but considering the important role of these two aspects and especially on the modification of parental modelling of PA.
INTRODUCTION

Several health-related factors such as birth weight, height, metabolic syndrome, unhealthy dietary patterns, and obesity have been shown to be influenced by socioeconomic status (SES) in adults (1-3). Moreover, it has been found that lower childhood SES is associated with less favourable health (1, 2) and higher cardiovascular disease risk factors in later life (4, 5).

Regarding the association between physical activity (PA) and SES, evidence suggests that it depends on the type of PA (6-10). Some studies reported that higher SES is related to higher sport participation (7, 8, 10), while others failed to observe differences in children's PA by SES (6, 9). However, most of these studies did not always take potential confounders into account such as body mass index (BMI), age or country differences. Country may be a key factor defining some important environmental influences on children behaviours.

Children's PA has been shown to be associated with a multidimensional range of social and environmental factors (11, 12). Parental factors, and maybe most prominently parental PA behaviour may be of crucial importance as indicated in recent reviews (12-14). A recent longitudinal study showed that, in Australia, parental modelling of PA was positively associated with children's PA (n=310; 10-12 years at baseline) (11). In addition, another study examined the association between several sociocultural factors and PA in a small sample of Danish children (n= 397; 9 years) and adolescents (n=213; 15 years). They observed associations with children's PA for mother's PA and parental participation in sports (15). Finally, other authors studied a sample of Hispanic parents and children (n= 85 parents and 80 children aged 3 to 5 years) and observed that parental activity levels are a powerful explanation of preschool children activity levels (16). There are no intervention studies so far focusing on the influence of parental PA modelling of children's PA, although some longitudinal and direct relationships have been found (17).

To the best of our knowledge, the independent associations of parental education as an indicator of SES and parental modelling with children's PA across different countries in Europe have not been studied. Further exploring such associations across countries that differ in PA environments and cultures can contribute to the development of intervention to promote PA.
The aim of the present study was therefore to examine the independent associations of parental education and parental PA patterns with children’s PA across Europe.

**SUBJECTS AND METHODS**

**Study population**

Data used in this report were derived from the ENERGY (EuropeaN Energy balance Research to prevent excessive weight Gain among Youth) project’s (18) cross sectional study (19). A sample size of 7000 school children, 1000 in each centre, was initially estimated. Finally, a total of 7214 children aged 10 to 12 years were recruited from a school-based cross sectional survey which took place in 2010 in seven European countries (Belgium, Greece, Hungary, the Netherlands, Norway, Slovenia and Spain). Samples were national representative in Greece, Hungary, the Netherlands and Slovenia. In Spain, schools of the regions of Aragón were selected; Belgium selected schools in Flanders and Norway selected schools in the southern regions of the country (19). More details about the study procedures and first results regarding overweight, obesity and obesogenic behaviours have been previously published (18-20). The study was performed following the ethical guidelines of the Declaration of Helsinki 1964 (revision of Edinburgh 2000), the Good Clinical Practice, and the legislation about clinical research in humans in each of the participating countries. The study protocol was approved by the Ethics Committee at each study centre and written informed consent signed by the parents was obtained from each participating child (19).

**Physical examinations**

Weight was measured in light clothing to the nearest 0.1 kg with an electronic scale (Seca 861). Height was measured without shoes to the nearest 0.1 cm using a stadiometer (Seca Leicester Portable Stadiometer). BMI was calculated as body weight (kg) divided by the height (m) squared (kg/m²) and used as indicator of total fatness. The intra-rater reliability rates ranged from 0.999 to 1.00 for weight and height measurements. The inter-rater reliability was 1.00 for weight and height measurements. Total body fatness has been found to be influenced by parental educational levels (21).
Parental education level (PEL)
PEL was estimated as an indicator of SES by means of a self-reported questionnaire completed by the parents and calculated from the PEL level questions. One parent (mother or father) was asked to fill in a questionnaire and to report on the years of education of both parents. The question was: ‘How many years of school education did you/ your partner complete?’ And the possible answers were: a) less than 7 years b) 7-9 years c) 10-11 years d) 12-13 years e) 14 years or more. These years take into account the different educational levels since preschool. Thus, the category “c” in this international dataset approximately distinguishes families with at least one caregiver who has completed medium or higher vocational, college or university training from other families. After preliminary analyses of the distribution of PEL, it was concluded that to recategorize into low, medium and high PEL was not possible due to the small sample size included in the low category. Thus, the variable was recorded into less than 14 years of education and 14 years or more. These two categories shall be referred to as low and high educational levels for both mother and father. This threshold was sensitive to split the sample as in overall a higher percentage of parents fell in the high category.

Physical activity
A variable regarding PA was calculated from the questionnaires in both children and parents. The variable recorded the total weekly amount of time (min) of PA (TTPA), which was the sum of the output of several questions about the time spent in sports activities and time spent on active transport. Questions about active transport included the numbers of days cycling and walking to work as well as the amount of minutes spent for those activities. Moreover, questions about the number of days per week practising any sport or PA in their leisure time as well as regarding the time spent in those activities were registered. Finally, TTPA was calculated as described above. This variable was calculated for each child and for the parent who filled out the questionnaire. The proportion of mothers and fathers who filled out the questionnaire was 82 % and 18%, respectively. The test-retest reliability and construct validity of the children’s questionnaire (22) and parental questionnaire (Singh et al., submitted) are reported elsewhere. From the children’s questionnaire 80% of PA´s items showed good to excellent test-retest reliability as indicated by intra-class correlation coefficients (ICCs) >0.60. Construct validity appeared to be good to excellent for 46% of the PA´s items.
**Statistical analysis**

Predictive Analytics SoftWare (PASW, version 18; SPSS Inc., Chicago, IL, USA) was used to perform the analyses. Statistical significance was set at $p<0.05$. The data are presented as mean ± standard deviation (SD) or percentages, unless otherwise stated. To achieve normality, the PA variables were transformed to the natural logarithm. One-way analysis of the variance (ANOVA) was used to test the gender differences of the descriptive variables.

Multiple linear regression models were used to study the association of PEL with TTPA after controlling for age, BMI z-score and parental PA level. PEL was entered into the models as dummy variables. Finally, multiple regression models were used to analyze the association of parental PA level with TTPA after controlling for confounders. Two different models were conducted: model I included age, BMI z-score and maternal educational level, model II included age, BMI z-score and paternal educational level. All the regression models were performed with the sample stratified by country in order to show the country-specific information. Moreover, due to low observed variance component associated with school ($<4.5\%$ for PEL and $<1\%$ for parent PA) the authors proceeded with models that did not include random effects for school and it was decided not to include it as a confounder.

**RESULTS**

Table 1 shows the descriptive characteristics of the study sample. The prevalence of children meeting the PA guidelines ($\geq60$ min/day) through the countries ranged from 11\% to 46\% in boys and from 6\% to 35\% in girls. The country-specific prevalence of parents meeting the PA guidelines for adults and percentages of low vs. high PEL are shown in table 2. The percentage of parents meeting the PA guidelines ranged from 16\% to 57\% through the countries. The percentage of mothers with high educational level was between 41\% and 78\%, while for fathers was between 37\% and 75\%. Table 3 shows the association of PEL with TTPA in children after adjusting for age, BMI z-score and parental PA levels. Maternal and paternal educational levels were associated with TTPA in girls in Greece and Spain as well as boys in Norway. Moreover, paternal educational level was positively associated with TTPA of boys in Hungary.
Table 1. Descriptive characteristics of European children in 2010.

<table>
<thead>
<tr>
<th></th>
<th>All (n=7213)</th>
<th>Boys (n=3443)</th>
<th>Girls (n=3770)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>11.7 ± 0.7</td>
<td>11.7 ± 0.8</td>
<td>11.6 ± 0.7</td>
<td>0.005</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>44.4 ± 10.4</td>
<td>44.4 ± 10.6</td>
<td>44.4 ± 10.3</td>
<td>0.817</td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.52 ± 0.09</td>
<td>1.52 ± 0.09</td>
<td>1.52 ± 0.08</td>
<td>0.058</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>19.1 ± 3.3</td>
<td>19.1 ± 3.4</td>
<td>19 ± 3.3</td>
<td>0.179</td>
</tr>
<tr>
<td>BMI z-score</td>
<td>0.4 ± 1.17</td>
<td>0.52 ± 1.21</td>
<td>0.3 ± 1.12</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>TTPA (min/w)²</td>
<td>281.3 ± 177.4</td>
<td>312.3 ± 181.7</td>
<td>253.1 ± 168.5</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Meeting PA guidelines for children (Y/N)%

<table>
<thead>
<tr>
<th>Country</th>
<th>All (%)</th>
<th>Boys (%)</th>
<th>Girls (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>16 / 84 [n=472]</td>
<td>13 / 87 [n=516]</td>
<td></td>
</tr>
<tr>
<td>Hungary</td>
<td>35 / 65 [n=467]</td>
<td>22 / 78 [n=561]</td>
<td></td>
</tr>
<tr>
<td>The Netherlands</td>
<td>24 / 76 [n=456]</td>
<td>12 / 88 [n=463]</td>
<td></td>
</tr>
<tr>
<td>Norway</td>
<td>46 / 54 [n=481]</td>
<td>35 / 65 [n=515]</td>
<td></td>
</tr>
<tr>
<td>Slovenia</td>
<td>34 / 66 [n=574]</td>
<td>27 / 73 [n=600]</td>
<td></td>
</tr>
<tr>
<td>Spain</td>
<td>25 / 75 [n=492]</td>
<td>9 / 91 [n=529]</td>
<td></td>
</tr>
</tbody>
</table>

All values are mean ± standard deviation, or % percentages.
BMI indicates body mass index; TTPA Total weekly amount of time of physical activity; Y Yes; N No.
Non-transformed data are presented in this table, but analyses were performed on log-transformed data.

Table 2. Country-specific prevalence of parents meeting PA guidelines and Low-High parental educational levels in 2010.

<table>
<thead>
<tr>
<th>Meeting PA guidelines for adults (Y/N)</th>
<th>Maternal Educational Level (L/H)</th>
<th>Paternal Educational Level (L/H)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium 16/84 (n=691)</td>
<td>22/78 (n=733)</td>
<td>25/75 (n=676)</td>
</tr>
<tr>
<td>Greece 16/84 (n=915)</td>
<td>59/41 (n=965)</td>
<td>63/37 (n=907)</td>
</tr>
<tr>
<td>Hungary 26/74 (n=880)</td>
<td>52/48 (n=903)</td>
<td>60/40 (n=773)</td>
</tr>
<tr>
<td>The Netherlands 28/72 (n=253)</td>
<td>30/70 (n=393)</td>
<td>33/67 (n=358)</td>
</tr>
<tr>
<td>Norway 57/43 (n=797)</td>
<td>38/62 (n=807)</td>
<td>40/60 (n=751)</td>
</tr>
<tr>
<td>Slovenia 47/53 (n=939)</td>
<td>52/48 (n=989)</td>
<td>61/39 (n=919)</td>
</tr>
<tr>
<td>Spain 29/71 (n=821)</td>
<td>28/72 (n=937)</td>
<td>31/69 (n=894)</td>
</tr>
</tbody>
</table>

All values are percentages (number of parents). H High; L Low; N No; Y Yes.
Table 3. Multiple linear regression models showing the association of parental educational levels with TTPA\(^1\) of European children in 2010.

<table>
<thead>
<tr>
<th>Maternal Educational Level</th>
<th>Paternal Educational Level</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Girls</strong></td>
<td><strong>Boys</strong></td>
</tr>
<tr>
<td>(\beta)</td>
<td>(R^2)</td>
</tr>
<tr>
<td>Belgium</td>
<td>0.025</td>
</tr>
<tr>
<td>Greece</td>
<td>0.162</td>
</tr>
<tr>
<td>Hungary</td>
<td>0.098</td>
</tr>
<tr>
<td>The Netherlands</td>
<td>0.169</td>
</tr>
<tr>
<td>Norway</td>
<td>0.091</td>
</tr>
<tr>
<td>Slovenia</td>
<td>0.01</td>
</tr>
<tr>
<td>Spain</td>
<td>0.18</td>
</tr>
</tbody>
</table>

\(\beta\), standardized regression coefficients; \(R^2\), coefficients of determination. \(^1\)Log-transformed data.
The models include adjustments for age, body mass index \(z\)-score and parental physical activity.
TTPA indicates total weekly amount of time of physical activity.

Table 4. Multiple linear regression models showing the association of parental physical activity\(^1\) with TTPA\(^1\) of European children in 2010.

<table>
<thead>
<tr>
<th>Model I</th>
<th>Model II</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Girls</strong></td>
<td><strong>Boys</strong></td>
</tr>
<tr>
<td>(\beta)</td>
<td>(R^2)</td>
</tr>
<tr>
<td>Belgium</td>
<td>0.192</td>
</tr>
<tr>
<td>Greece</td>
<td>0.195</td>
</tr>
<tr>
<td>Hungary</td>
<td>0.033</td>
</tr>
<tr>
<td>The Netherlands</td>
<td>-0.028</td>
</tr>
<tr>
<td>Norway</td>
<td>0.116</td>
</tr>
<tr>
<td>Slovenia</td>
<td>0.121</td>
</tr>
<tr>
<td>Spain</td>
<td>0.165</td>
</tr>
</tbody>
</table>

\(\beta\), standardized regression coefficients; \(R^2\), coefficients of determination. \(^1\)Log-transformed data.
Model I includes adjustments for age, body mass index \(z\)-score and maternal educational level.
TTPA indicates total weekly amount of time of physical activity.
Table 4 shows the association of parental PA level with TTPA in European children after adjusting for age, BMI z-score and PEL. Parental PA level was positively associated with TTPA in girls in 5 and 4 of the 7 countries involved (model I and model II, respectively). Moreover, positive associations were found between parental PA and TTPA in boys in 4 of the 7 countries in model I, but only 2 countries in model II.

**DISCUSSION**

The main finding of this study was that PEL and parental PA were both associated with children's TTPA. In overall, parental modelling of PA showed a stronger association with child's PA levels for more than half of the countries involved for both girls and boys, while PEL was associated with child's PA only in 2 and 3 countries for girls and boys, respectively. A gender and country-specific effect was found for these relationships.

Our results agree with those who found a positive influence of educational level (in our study PEL) on children's PA (7, 8, 10) and contrast with those who did not find any influence of educational level on PA (6, 9). Despite most of them observed an association of socioeconomic factors such as parental education with PA, none included an adjustment for body composition components. A study in Portugal in 507 children (8-15 years) observed that those subjects with high parental education had higher sport participation scores than their peers with low parental education, between other factors. However, these authors did not use any adjustment to account the possible effect of other variables (8). The present study shows that a high PEL is positively associated with TTPA in children from both genders after adjustments for age, BMI and parental PA in several countries across Europe.

The home environment seems to be more relevant than the neighbourhood environment in influencing children's PA (11, 23). Moreover, parental role modelling has been suggested in recent reviews as one of these important factors influencing children's PA (12-14, 23). In the current research, parental modelling of PA positively influences the PA levels of both genders after adjusting for age, BMI and PEL in most of the studied countries, which is in accordance with previous studies (10, 11, 15). Important aspects to highlight from our study compared to the
others (11, 15) is the use of several confounders including PEL in order to assess the independent role of parental PA on children’s PA, but also the possibility to analyze these relationships across different European countries.

The influences on children’s PA behaviours are multidimensional (12), thus, it is important to assess the role of each sociocultural factor independently from the others that could have a potential effect. To the best of our knowledge this is the first study analyzing the independent influence of PEL and parental modelling of PA on children’s PA and also showing the gender and country-specific differences across a large European sample in seven countries. These findings suggest the ideal direction for future research focus on increasing child’s PA through intervention programmes. Interventions should improve the awareness of parents about their modelling of child’s PA using educational tasks and workshops. Special interest should be paid on parents with low education level in order to counteract this negative influence for children’s PA.

Strengths of the present research are the use of a well gender-balanced and heterogeneous large sample of 10-12-year-old children in seven European countries and the possibility to give gender-specific information. In addition, the use of several adjustments and showing how these relationships across countries are, adds to the current findings. The present study has several limitations. The cross-sectional nature of this study limits the ability to determine any causality in the results. More prospective and intervention studies improving child’s PA through increasing of parental knowledge and modelling of PA are needed. Moreover, PA was assessed using self-reported questionnaire and it is possible that participants do not recall their activities accurately. The parental PA was calculated based on the parent who filled out the questionnaire, thus the different PA behaviour of the parents could influence the associations.
CONCLUSION

Our observations suggest that PEL and parental modelling of PA are two independent factors from the home environment associated with children’s PA, but the relationships are gender and country-specific. Intervention strategies focus on increasing children’s PA levels should consider the important role of these two aspects and especially on the modification of the parental PA habits. Moreover, the role of other factors such as fitness should be considered in future studies as well as the use of a more complete spectrum of exposures for parental behaviours (i.e. income or ownership cars) or more precise measurements for PA (i.e. accelerometer). These interventions could be useful in the fight against the epidemic of obesity through increasing children’s PA.

ACKNOWLEDGEMENTS

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References
15. McMinn AM, van Sluijs EM, Wedderkopp N, Froberg K, Griffin SJ. Sociocultural
ASSOCIATIONS OF PARENTAL SPORTS AND TV TIME AS MEDIATORS OF PARENTAL EDUCATION DIFFERENCES IN CHILDREN’S SPORTS AND TV TIME: THE ENERGY-PROJECT

Juan Miguel Fernández-Alvira, Saskia te Velde, Amika Singh, David Jiménez-Pavón, Ilse De Bourdeaudhuij, Elling Bere, Yannis Manios, Eva Kovacs, Nataša Jan, Luis A Moreno, Johannes Brug

Submitted
ABSTRACT

Purpose: we assessed whether differences in children’s sport participation and TV time according to parental education were mediated by parental modelling (parental sports participation and TV time). Moreover, we explored the differences between parental and child reports on parental sports participation and TV time as potential mediators.

Methods: 5729 children and 5183 parents participating in the ENERGY-project provided information on sports participation and TV time using validated self-report questionnaires. Multilevel country-specific mediation models were analyzed in Mplus, assessing the potential mediation effect of parental self-reports and child-reports on parental sports participation and TV time.

Results: Significant mediation effect was found for parental modelling as assessed by self-reported TV time in four countries (Greece, Hungary, the Netherlands and Slovenia), with the highest proportion mediated for Slovenia (40%) and the lowest for Greece (21%). Child-reported parental TV time showed mediation effect in Greece only. Parental self-reported sports participation showed significant mediation effect only in Greece. With child-reported parental sports participation, significant mediation was observed in Greece and Norway.

Conclusions: Parental behaviours appear to be important in explaining parental educational differences in children’s sports participation and TV time. However, child reports on parental behaviour appear to be more relevant than parents’ self-reports as correlates of children’s own sports participation and TV time, while parental self-reports appear to be more relevant to explain parental educational differences in children’s sports participation and TV time.
INTRODUCTION

Lower socioeconomic status (SES) is associated with less favourable health outcomes, such as overweight (1-3), and health-related behaviours (4), including physical activity (PA) and sedentary behaviours (SB) in children (5). Children’s PA and SB have been also related to parental PA and SB. For instance, Jago et al (6) showed that higher parental TV viewing was associated with higher child TV viewing and more likely to exceed recommendations. Fuemmeler et al (7) showed positive association between parental directly measured PA and children’s PA. In addition, associations of SES with PA and TV time among adults may suggest that adults, and thus parents, of lower SES engage less in PA and spend more time watching TV. The less favourable behavioural patterns in children from lower SES groups may be caused by parental modelling, i.e. because of unfavourable example behaviour from the parents, these children are less likely to engage in PA and more likely to be sedentary (5, 6, 8-10). However, formal analyses exploring mediating pathways between SES indicators, parental PA and SB and children’s PA and SB have not been reported before.

In previous literature, parental self-reports on their behaviours have been usually taken into account to explore associations of parental behaviour with children’s PA and TV time (10-12). However, there is evidence that parental reports and child perception of parental energy balance-related behaviours may differ, and child perceptions may be more predictive of actual child behaviours compared to parental reports (13-15). Theoretical frameworks like family systems theory stress the child perspective as equally important as parental reports when capturing information on child-parent relationships (16), suggesting that the child’s perspective may lead to better discrimination of children at risk for negative outcomes, as parental reports may be subject to social desirability bias.

The first aim of the present study was therefore to explore whether differences in two specific PA (i.e. sport participation) and sedentary (i.e. TV time) behaviours according to parental education (i.e. one important indicator of SES), were mediated by parental sports participation and TV time. The second aim was to explore the differences between parental and child reports on parental sports participation and TV time as potential mediators.
METHODS

Study design
The cross-sectional study of the ENERGY project (17) (www.projectenergy.eu) on the prevalence of overweight and on the most important energy balance-related (EBRBs) and their socio-demographic, personal and family and school environmental correlates was carried out in Belgium, Greece, Hungary, the Netherlands, Norway, Slovenia and Spain, among pupils in the final years of primary education (aged 10 to 12) (18). Data collection took place between March and July 2010. Detailed descriptions of the ENERGY rationale, design, sampling, procedures and school-based survey methodology are published elsewhere (17, 18). The study was approved by the corresponding ethics committees in the involved countries. Written informed consent was obtained by all participants prior their enrolment. The study was performed following the ethical guidelines of the Declaration of Helsinki 1964 (revision of Edinburgh 2000), the Good Clinical Practice, and the legislation about clinical research in humans in each of the participating countries.

Study sample
Samples were national representative in Greece, Hungary, the Netherlands and Slovenia. In Spain, schools from Aragon were selected; Belgium selected schools in Flanders and Norway selected schools in the southern regions of the country (18). Based on previous cross-European studies (19) a minimum sample of 1000 children per country (a total of 7000 children) and one parent for each child was aimed for, allowing analyses of the associations between correlates and specific EBRBs, within-country analyses as well as between-country comparisons. A total of 7214 children aged 10-12 years participated in the school-based survey. More details about the study procedures and results regarding overweight and obesity prevalence, obesogenic behaviours and socioeconomic correlates have been published (17, 18, 20, 21).

Parental educational level
Parents reported their own level of education, as well as the level of education of the other parent/caregiver, on a 5-point answering scale (< 7 years; 7-9 years; 9-11 years; 12-13 years; ≥ 14 years). As educational systems differ considerably across Europe, the number of years of formal education was used as an indicator for level
of education. After preliminary analyses of the distribution of the variable, it was concluded that recategorizing into low, medium and high parental education levels was not possible due to the small sample size included in the low category. Therefore, the variable was categorized as being high (i.e. at least one parent more than 14 years of education) or low (i.e. both parents less than 14 years of education), approximately distinguishing families with at least one caregiver who has completed medium or higher vocational, college or university training from other families (22).

**Children’s Sports and TV time, main outcome variables**

Sports engagement and TV time were assessed by the child questionnaire. The children completed questionnaires during school time. Test-retest reliability was tested by administering the questionnaire twice with one-week interval among 720 children across the participating countries (23). Organized sports participation was assessed with specific questions about how many hours per week children participated in one or two sports ($IC_{test-retest}=0.74$ and $1.00$). Based on the answers, average time of sports in minutes per day was calculated. TV time was assessed separately for weekdays and weekend days by two questions about time spent watching TV (including video and DVDs) ($IC_{test-retest}=0.67$ and $0.68$). Mean TV time in hours per day was calculated.

**Parental sports and TV time as potential mediators**

*Parent reported*: Sports engagement and TV time were assessed by the parental self-reported questionnaire. Test-retest reliability was tested by administering the questionnaire twice with one week interval in between among 316 parents of 10-to-12 children across six participating countries (24). Organized sports participation was assessed separately for weekdays and weekend days by two self-reported questions about how many days ($IC_{test-retest}=0.75$ and $0.89$) and how many hours per week ($IC_{test-retest}=0.79$ and $0.88$) parents participated in sports. Based on the answers, average time of sports participation per week was calculated, expressed in minutes per day. TV time was assessed separately for weekdays and weekend days by a self-reported question about time spent watching TV (including video and DVD) ($IC_{test-retest}=0.79$ and $0.83$). After calculating total weekly TV time, and for the purposes of the analyses, the total hours/day of TV was taken into account.
Child reported: Children were asked in two separate questions about how often their parents/care givers do physical activity/sports ($\text{ICC}_{\text{test-retest}}=0.67$) and about how often their parents/care givers watch TV ($\text{ICC}_{\text{test-retest}}=0.68$) on a five-point scale. Response options were as follows: “Never”, “Not often”, “Sometimes”, “Often” and “Always”.

Anthropometric measurements
Trained research assistants measured body height, weight and waist circumference (WC) of the children. Children were measured in light clothing without shoes. Body height was measured with a SECA Leicester Portable stadiometer (to the nearest 0.1 cm). Weight was measured with a calibrated electronic scale SECA 861 (to the nearest 0.1 kg), and WC with a SECA 201 measuring tape (to the nearest 0.1 cm). Two readings of each measurement were obtained, taking a third measurement if the two first readings differed more than 1%. Body mass index (BMI) [calculated as body weight (kg) divided by the height (m) squared (kg/m²)] and weight categories based on the International Obesity Task Force criteria (IOTF) (25) were calculated. Self-reported parental weight and height were obtained via parental questionnaire and used to calculate parental BMI, to be included in the analyses as a potential confounder.

Statistical analysis
Descriptive statistics and unadjusted analyses (ANOVA and Chi-square) were performed using the Statistical Package for the Social Sciences (SPSS) (Version 20.0 SPSS Inc., Chicago, IL).

Mediation analyses
To assess whether the associations between parental education and children’s sports and TV time were mediated by parental modelling (parental sports and TV time), mediation models were analyzed in Mplus (26) using the INDIRECT command and adjusting for the clustered design (participants nested in schools, using the CLUSTER command). Mplus provides estimates for the different paths depicted in Figure 1. We will present the results for the total association (path-c) between parental education ($X$) and children sports and TV time ($Y$); the association between the presumed mediator ($M$) and the predictor variable ($X$) (a-path); the
association between M and Y (b-path), the indirect mediated path way (a*b), and the direct association (c’), which is the association between X and Y adjusted for M(27). The mediated effect (a*b) was estimated by MacKinnon’s product-of-coefficients test(28). The mediated proportions were calculated by dividing the mediation effect by the total effect (c-path) [(a*b)/c], only if the mediated path way reached statistical significance. For the direct (c’) and total associations (c) 95% confidence intervals (CI) were constructed with the calculated standard errors to assess statistical significance. Bootstrap corrected CIs were calculated for indirect, mediated effects.

Chi-square goodness-of-fit test showed that country-specific models fitted better the data compared to overall sample models. Therefore, country-specific models are presented and discussed below. In order to be able to compare the strengths of the different paths between models using parent and child report of the parental behaviours, a-paths and b-paths are reported using standardized estimators to overcome the problem of the different scales used for the parent and child reported variables. All models were adjusted for child and parent age, BMI and gender.

Figure 1. Mediation model. X: predictor variable; Y: outcome variable; M: mediator variable; a path: association between predictor (X) and potential mediator (M); b path: association between potential mediator (M) and outcome variable (Y); c path: overall association between predictor variable (X) and outcome variable (Y); c’ path: direct effect (unmediated) of predictor variable (X) on outcome variable (Y)

Parental education differences in children’s sports and TV time  109
RESULTS

Participant characteristics and mean sports and TV time by parental education level are described in table 1. Lower educated parents were significantly younger and showed higher overweight prevalence compared to higher educated parents. As reported before (21), children with lower educated parents had higher prevalence of overweight. Significant differences in TV time and sports were found for both children (reported before, please see (21)) and parents according to parental education.

Table 1. Descriptive characteristics for children and parents.

<table>
<thead>
<tr>
<th></th>
<th>Children</th>
<th></th>
<th>Parents</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>low PEL</td>
<td>high PEL</td>
<td>low PEL</td>
<td>high PEL</td>
</tr>
<tr>
<td>N</td>
<td>2012</td>
<td>3717</td>
<td>1686</td>
<td>3497</td>
</tr>
<tr>
<td>Age, mean (SD)</td>
<td>11.7*</td>
<td>0.8</td>
<td>11.6</td>
<td>0.7</td>
</tr>
<tr>
<td>Gender, n male(%)</td>
<td>944</td>
<td>46.9</td>
<td>1736</td>
<td>46.7</td>
</tr>
<tr>
<td>% overweight (%)</td>
<td>29.5**</td>
<td>21.1</td>
<td>43.4**</td>
<td>35.4</td>
</tr>
</tbody>
</table>

TV time self-report (min/day)
mean (SD)
115.5** 62.6 103.9 57.7 116.7** 59 96.2 53
Sports participation Self-report (min/day)
mean (SD)
30.7** 24.4 33.9 23.1 18.4** 21.2 23 21.6
Parental TV time children’s report
mean (SD)
- - - - 3.5** 0.9 3.3 0.8
Parental sports participation children’s report
mean (SD)
- - - - 3.1** 1.2 3.3 1

*p<0.05; **p<0.001; † scale/rage 1-5; PEL: parental education level; SD: standard deviation

Parental education and children’s sports and TV time (c-path)
Higher parental education was associated with less TV time in four out of the seven countries, namely Greece, Hungary, the Netherlands and Slovenia (tables 2 and 3), and with sports participation in four countries, namely Greece, Hungary, Norway and Spain (tables 4 and 5).
Associations between parental education and parental sports and TV time (a-path)
Significant and inverse associations with parental education were found for self-reported parental TV time in all countries (table 2); parental education was inversely related with child reports on parental TV time, in four countries (Belgium, Greece, the Netherlands and Norway; table 3). Significant positive associations between parental education and parental sports participation were found in four countries (Greece, Hungary, the Netherlands and Slovenia) for parental self-reports of sports (table 4), and in three countries (Greece, Norway and Slovenia) for child-reports (table 5).

Associations between parental sports and TV time and children’s sports and TV time (b-path)
Significant positive associations were found in all countries for both self-reported and child-reported parental TV time (table 2) with children’s TV time (table 3). Moreover, significant positive associations were found in all countries except Hungary and the Netherlands for self-reported parental sport participation (table 4) and in all countries except the Netherlands for child-reported parental sport participation (table 5) with children’s sport participation.

Mediation effects (a*b)
Indirect effects are shown in the 4th column of tables 2 to 5. Mediation effects of parent self-reported TV time of the difference in children's TV time according to parental education (table 2) were statistically significant in four countries (Greece, Hungary, the Netherlands and Slovenia), with the highest proportion mediated for Slovenia (40%) and the lowest for Greece (21%). With child-reported parental TV time, significant mediation was found in Greece only (table 3). The difference in children's sports participation according to parental education was mediated by parental self-reported sports participation in Greece only (table 4). With child-reported parental sports participation (table 5), significant mediation was observed in Greece and Norway.

Direct association (c’-path)
The difference in children's TV time according to parental education remained significant after adjustment for the mediator in Greece and Hungary, but not in the Netherlands and Slovenia (table 2). All other differences according to parental education remained significant after taking the mediator into account.
Table 2. Regression coefficients (B) and 95% confidence intervals (CI) as results from multilevel mediation analyses testing association between parental education level and children’s TV time (hours/day) for each participating country.

<table>
<thead>
<tr>
<th>Country</th>
<th>(path c)</th>
<th>(path a)</th>
<th>(path b)</th>
<th>(a*b)</th>
<th>(path c')</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium (n=625)†</td>
<td>0.11 (-0.17; 0.38)</td>
<td>-0.16 (-0.23; -0.08)</td>
<td>0.28 (0.22; 0.35)</td>
<td>-0.12 (-0.19; -0.06)</td>
<td>0.23 (-0.02; 0.48)</td>
</tr>
<tr>
<td>Greece (n=839)†</td>
<td>-0.19 (-0.29; -0.20)</td>
<td>-0.19 (-0.26; -0.11)</td>
<td>0.12 (0.03; 0.21)</td>
<td>-0.04 (-0.07; -0.01)</td>
<td>-0.15 (-0.24; -0.06)</td>
</tr>
<tr>
<td>Hungary (n=743)†</td>
<td>-0.26 (-0.44; -0.08)</td>
<td>-0.21 (-0.28; -0.14)</td>
<td>0.14 (0.06; 0.22)</td>
<td>-0.06 (-0.11; -0.02)</td>
<td>-0.20 (-0.38; -0.02)</td>
</tr>
<tr>
<td>the Netherlands (n=309)†</td>
<td>-0.47 (-0.86; -0.07)</td>
<td>-0.22 (-0.32; -0.11)</td>
<td>0.27 (0.08; 0.46)</td>
<td>-0.14 (-0.28; -0.01)</td>
<td>-0.32 (-0.71; 0.06)</td>
</tr>
<tr>
<td>Norway (n=664)†</td>
<td>-0.06 (-0.20; 0.08)</td>
<td>-0.20 (-0.27; -0.12)</td>
<td>0.14 (0.07; 0.22)</td>
<td>-0.06 (-0.10; -0.02)</td>
<td>0.00 (-0.15; 0.15)</td>
</tr>
<tr>
<td>Slovenia (n=834)†</td>
<td>-0.20 (-0.35; -0.05)</td>
<td>-0.19 (-0.26; -0.11)</td>
<td>0.20 (0.12; 0.27)</td>
<td>-0.08 (-0.13; -0.03)</td>
<td>-0.12 (-0.25; 0.01)</td>
</tr>
<tr>
<td>Spain (n=832)†</td>
<td>-0.04 (-0.17; 0.09)</td>
<td>-0.14 (-0.26; -0.03)</td>
<td>0.21 (0.13; 0.30)</td>
<td>-0.07 (-0.14; 0.00)</td>
<td>0.03 (-0.10; 0.16)</td>
</tr>
</tbody>
</table>

For an explanation of a, b, c, c’, please see Figure 1
†Models adjusted for children’s age, BMI and gender, parental BMI, age and gender
*Standardized model results

Statistically significant associations are shown in bold
Table 3. Regression coefficients (B) and 95% confidence intervals (CI) as results from multilevel mediation analyses testing association between parental education level and children’s TV time (hours/day) for each participating country.

<table>
<thead>
<tr>
<th>Country</th>
<th>Total association between parental education and children’s TV time (path c) B (95% CI)</th>
<th>Association between parental education and child-reported parental TV time (path a) B (95% CI)*</th>
<th>Association between child-reported parental TV time and children’s TV time (path b) B (95% CI)*</th>
<th>Indirect association (a*b) B (95% CI)</th>
<th>Direct association, after adjustment for mediator (path c’) B (95% CI)</th>
<th>Percentage mediated (a*b/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium (n=623)†</td>
<td>0.11 (-0.17 ; 0.39)</td>
<td>-0.01 (-0.17 ; -0.02)</td>
<td>0.16 (0.10 ; 0.22)</td>
<td>-0.04 (-0.08 ; -0.01)</td>
<td>0.15 (-0.13 ; 0.44)</td>
<td>-</td>
</tr>
<tr>
<td>Greece (n=839)†</td>
<td>-0.19 (-0.29 ; -0.10)</td>
<td>-0.08 (-0.15 ; -0.01)</td>
<td>0.18 (0.12 ; 0.24)</td>
<td>-0.03 (-0.05 ; -0.01)</td>
<td>-0.17 (-0.26 ; -0.07)</td>
<td>16%</td>
</tr>
<tr>
<td>Hungary (n=743)†</td>
<td>-0.26 (-0.44 ; -0.07)</td>
<td>-0.07 (-0.15 ; 0.02)</td>
<td>0.30 (0.22 ; 0.38)</td>
<td>-0.04 (-0.09 ; 0.00)</td>
<td>-0.21 (-0.37 ; -0.06)</td>
<td>-</td>
</tr>
<tr>
<td>the Netherlands (n=309)†</td>
<td>-0.47 (-0.86 ; -0.08)</td>
<td>-0.11 (-0.21 ; -0.01)</td>
<td>0.43 (0.24 ; 0.61)</td>
<td>-0.11 (-0.24 ; 0.02)</td>
<td>-0.36 (-0.68 ; -0.03)</td>
<td>-</td>
</tr>
<tr>
<td>Norway (n=663)†</td>
<td>-0.06 (-0.20 ; 0.09)</td>
<td>-0.08 (-0.13 ; -0.04)</td>
<td>0.17 (0.10 ; 0.25)</td>
<td>-0.03 (-0.05 ; -0.01)</td>
<td>-0.03 (-0.17 ; 0.12)</td>
<td>-</td>
</tr>
<tr>
<td>Slovenia (n=834)†</td>
<td>-0.21 (-0.36 ; -0.05)</td>
<td>-0.09 (-0.18 ; 0.01)</td>
<td>0.28 (0.20 ; 0.35)</td>
<td>-0.05 (-0.11 ; 0.01)</td>
<td>-0.16 (-0.28 ; -0.03)</td>
<td>-</td>
</tr>
<tr>
<td>Spain (n=836)†</td>
<td>-0.04 (-0.17 ; 0.09)</td>
<td>0.04 (-0.01 ; 0.10)</td>
<td>0.19 (0.12 ; 0.27)</td>
<td>0.02 (-0.01 ; 0.04)</td>
<td>-0.06 (-0.18 ; 0.07)</td>
<td>-</td>
</tr>
</tbody>
</table>

For an explanation of a, b, c, c’, please see Figure 1
†Models adjusted for children’s age, BMI and gender, parental BMI, age and gender
*Standardized model results
Statistically significant associations are shown in bold
Table 4. Regression coefficients (B) and 95% confidence intervals (CI) as results multilevel mediation analyses testing associations between parental education level and children's sports participation (min/day).

<table>
<thead>
<tr>
<th>Country</th>
<th>Total association between parental education and children's sports participation</th>
<th>Association between parental education and self-reported parental sports participation</th>
<th>Association between self-reported parental sports participation and children's sports participation</th>
<th>Indirect association</th>
<th>Direct association, after adjustment for mediator</th>
<th>Percentage mediated (a*b/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium (n=624)†</td>
<td>3.22 (-1.57 ; 8.01)</td>
<td>0.06 (-0.17 ; 0.14)</td>
<td>0.11 (0.03 ; 0.19)</td>
<td>0.40 (-0.04 ; 0.83)</td>
<td>2.82 (-1.90 ; 7.55)</td>
<td>-</td>
</tr>
<tr>
<td>Greece (n=839)†</td>
<td>5.37 (2.69 ; 8.05)</td>
<td>0.11 (0.05 ; 0.18)</td>
<td>0.11 (0.05 ; 0.18)</td>
<td>0.49 (0.11 ; 0.87)</td>
<td>4.89 (2.22 ; 7.55)</td>
<td>9%</td>
</tr>
<tr>
<td>Hungary (n=742)†</td>
<td>7.61 (4.23 ; 10.99)</td>
<td>0.10 (0.02 ; 0.18)</td>
<td>0.05 (-0.02 ; 0.11)</td>
<td>0.23 (-0.12 ; 0.59)</td>
<td>7.37 (3.95 ; 10.80)</td>
<td>-</td>
</tr>
<tr>
<td>the Netherlands (n=309)†</td>
<td>-2.48 (-8.28 ; 3.32)</td>
<td>0.16 (0.04 ; 0.29)</td>
<td>0.09 (-0.05 ; 0.23)</td>
<td>0.73 (-0.42 ; 1.87)</td>
<td>-3.21 (-9.15 ; 2.73)</td>
<td>-</td>
</tr>
<tr>
<td>Norway (n=664)†</td>
<td>3.87 (1.11 ; 6.64)</td>
<td>0.06 (-0.05 ; 0.16)</td>
<td>0.08 (0.00 ; 0.16)</td>
<td>2.24 (-0.29 ; 0.78)</td>
<td>3.63 (1.13 ; 6.13)</td>
<td>-</td>
</tr>
<tr>
<td>Slovenia (n=836)†</td>
<td>0.81 (-2.27 ; 3.89)</td>
<td>0.26 (0.18 ; 0.35)</td>
<td>0.12 (0.03 ; 0.20)</td>
<td>1.51 (0.41 ; 2.62)</td>
<td>-0.70 (-4.05 ; 2.64)</td>
<td>-</td>
</tr>
<tr>
<td>Spain (n=835)†</td>
<td>5.28 (0.86 ; 9.71)</td>
<td>-0.01 (-0.09 ; 0.06)</td>
<td>0.15 (0.09 ; 0.21)</td>
<td>-0.12 (-0.73 ; 0.49)</td>
<td>5.41 (0.91 ; 9.90)</td>
<td>-</td>
</tr>
</tbody>
</table>

For an explanation of a, b, c, c', please see Figure 1
†Models adjusted for children's age, BMI and gender, parental BMI, age and gender
*Standardized model results

Statistically significant associations are shown in bold
Table 5. Regression coefficients (B) and 95% confidence intervals (CI) as results from multilevel mediation analyses testing association between parental education level and children’s sports participation (min/day).

<table>
<thead>
<tr>
<th>Country</th>
<th>Total association between parental education and children’s sport participation</th>
<th>Association between parental education and child-reported parental sports participation</th>
<th>Association between child-reported parental sports participation and children’s sports participation</th>
<th>Indirect association</th>
<th>Direct association, after adjustment for mediator</th>
<th>Percentage mediated (a*b/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium (n=624)†</td>
<td>3.21 (-0.60 ; 8.02)</td>
<td>0.05 (-0.04 ; 0.14)</td>
<td>0.09 (0.01 ; 0.19)</td>
<td>0.28 (-0.39 ; 0.95)</td>
<td>2.93 (-2.11 ; 7.96)</td>
<td>-</td>
</tr>
<tr>
<td>Greece (n=839)†</td>
<td>5.36 (2.68 ; 8.03)</td>
<td>0.12 (0.06 ; 0.18)</td>
<td>0.18 (0.11 ; 0.24)</td>
<td>0.89 (0.35 ; 1.42)</td>
<td>4.47 (1.83 ; 7.11)</td>
<td>17%</td>
</tr>
<tr>
<td>Hungary (n=743)†</td>
<td>7.61 (4.23 ; 10.99)</td>
<td>0.06 (-0.01 ; 0.12)</td>
<td>0.21 (0.15 ; 0.27)</td>
<td>0.59 (-0.06 ; 1.21)</td>
<td>7.03 (3.94 ; 10.12)</td>
<td>-</td>
</tr>
<tr>
<td>the Netherlands (n=309)†</td>
<td>-2.48 (-8.28 ; 3.32)</td>
<td>0.03 (-0.08 ; 0.13)</td>
<td>0.08 (-0.04 ; 0.19)</td>
<td>0.09 (-0.29 ; 0.48)</td>
<td>-2.58 (-8.54 ; 3.39)</td>
<td>-</td>
</tr>
<tr>
<td>Norway (n=664)†</td>
<td>4.01 (1.29 ; 6.74)</td>
<td>0.13 (0.06 ; 0.21)</td>
<td>0.21 (0.14 ; 0.28)</td>
<td>1.49 (0.52 ; 2.45)</td>
<td>2.52 (0.14 ; 4.91)</td>
<td>37%</td>
</tr>
<tr>
<td>Slovenia (n=836)†</td>
<td>0.81 (-2.30 ; 3.91)</td>
<td>0.20 (0.12 ; 0.29)</td>
<td>0.17 (0.10 ; 0.24)</td>
<td>1.67 (0.55 ; 2.79)</td>
<td>-0.86 (-3.64 ; 1.92)</td>
<td>-</td>
</tr>
<tr>
<td>Spain (n=836)†</td>
<td>5.30 (0.87 ; 9.73)</td>
<td>0.02 (-0.07 ; 0.10)</td>
<td>0.11 (0.05 ; 0.18)</td>
<td>0.09 (-0.49 ; 0.68)</td>
<td>5.21 (0.71 ; 9.70)</td>
<td>-</td>
</tr>
</tbody>
</table>

For an explanation of a, b, c, c’, please see Figure 1
†Models adjusted for children’s age, BMI and gender, parental BMI, age and gender
*Standardized model results

**Statistically significant associations are shown in bold**
**DISCUSSION**

The present study explored whether parental TV time and sports participation mediated parental education differences in children’s TV time and sports. The results indicate that parents’ example behaviour may be one factor that explains why children from lower educated parents are more likely to engage in less healthy behaviours. The fact that evidence for partial mediation, and in some countries no evidence for mediation was found indicates that parental modelling is not the only relevant issue. The results show significant associations between self-reported parental TV time and children’s TV time in all included countries, confirming that parental example behaviour is indeed of importance for children’s TV habits. Regarding PA, the weaker associations or even the lack of associations between parental PA and children’s PA may be due to the fact that parents and pre-adolescents may not practice sports together most of the time (29) and engagement in sports takes place outside the home environment; i.e. children may not see their parents engaging in sports that often, and parental PA modelling may thus be weaker as compared to TV time that takes place mostly at home.

Our results also show that in general, parental education was more strongly associated with parental sports and TV time when using parent self-reports than child-reported parental behaviour (a-paths). This may be because parent self-reports are more likely to be closer to reality than child-reports, for example because children will not be able to always observe their parents’ TV and sports habits. Additionally, parent self-reports were registered as continuous variables, while child reports were based on five-point-scales, with lower variability and possibly more subjective rating. Social desirability bias may affect parent self-reports (30), and therefore associations may be stronger. Finally, test-retest reliability for child reports were somewhat lower compared to parent reports ICCs (23, 24). On the other hand, child-reported parental behaviour appears to be stronger associated with the children’s own behaviour (b-paths). The fact that children’s perceptions of their parents’ behaviour is more relevant for their own health behaviours than what parental reports, has been reported before (13-15) and fits in the framework of behavioural theories about role modelling stating that children’s vicarious identification with their parents do influence their behaviours through social learning processes (31). Correlations between child-reported and self-reported parental sports and TV time were significant but low (sports: 0.231; TV time: 0.260), suggesting that what children see or perceive of their parents’ TV and sports
time is not the same as what their parents do or report regarding these behaviours.

Interpreting the results discussed above, it shows that a measure of parental behaviour can, at least partly, explain the parental educational differences in children’s TV and sports time. However, mostly due to the stronger association with parental educational level, parental self-reports acted as stronger mediators compared to the child reported parental behaviours. Therefore, more research is needed to identify what aspects of parental behaviour are most relevant and most important with respect to observational learning of energy expenditure behaviours and how we can best measure this.

This study is subject to a number of limitations. First, the results are based on cross-sectional data, and therefore no causality can be established. Second, data on TV time and sports were based on self-reports, and therefore may be biased. Nevertheless, the measures showed good test-retest reliability and construct validity (23, 24). In addition, the differences in response rates at school level were important, and may have an impact on the external validity of the findings. Finally, sports and TV time were assessed via questionnaires, and it is possible that the participants did not recall their activities accurately, especially in the case of child reports on parental behaviours. The use of more precise methods of PA measurement (i.e. accelerometers) and the use of completely equivalent questions in child and parent reports may improve the accuracy of the results. Strengths of the present study are the cross-European heterogeneous large sample of children from seven countries and the standardized data collection protocol across the different countries, and the state-of-the art multilevel mediation analyses conducted.
CONCLUSION

Parental behaviours appear to be relevant in explaining parental educational differences in children’s sports participation and TV time. However, child reports of parental sports and TV time appear to be more relevant than parents’ self-report as correlates of children’s own sports and TV time, while parental self-reported behaviours appear to be more relevant to explain parental educational differences in children’s TV and sports time. More research is needed to identify what aspects of parental behaviour are most relevant and most important regarding children’s energy balance-related behaviours.

ACKNOWLEDGEMENT

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References
12. Salmon J, Timperio A, Telford A, Carver A, Crawford D. Association of family environment with children’s television viewing and with low level of physical


The aim of this thesis was to explore the role of several energy balance-related behaviours (EBRBs; i.e. sugared-sweetened drinks, breakfast skipping, active transportation to school, sports engagement, TV and computer time and sleep duration) in the explanation of parental education and ethnic inequalities in childhood overweight in children in different countries across Europe. The first part of this thesis (chapters 2 and 3) focused on the mediating role of children’s EBRBs in the associations between socioeconomic variables and children’s body composition. The second part of the thesis (chapters 4, 5 and 6) focused on the associations between parental education and children’s EBRBs. This discussion chapter summarizes the answers obtained regarding the research questions stated in the introductory chapter of this thesis and reflects on the results of the studies, including several methodological limitations. The results are discussed regarding their relevance for public health interventions, aiming to reduce childhood overweight and obesity in lower socio-economic status (SES) groups. Finally, some recommendations for further research are presented.

**SUMMARY OF THE MAIN FINDINGS**

**Part One:**
**Mediating role of children’s EBRBs in the associations between socioeconomic determinants and children’s body composition**

In the General Introduction of this thesis, a series of research questions that were addressed in this thesis were presented. Hereafter the results that contribute to answering these research questions are summarized.

**Are EBRBs mediating the associations between parental education and children’s body composition?**
Chapter 2 explored if several EBRBs could help to explain differences in children’s body composition according to parental education. Sugared-sweetened drinks intake, breakfast skipping, sports participation, TV time and computer time partially mediated the association between parental education and children’s body composition, while no mediation effect was found for active transportation to school and usual sleep duration. The results of this study thus suggest that tailored overweight and obesity prevention strategies in low SES preadolescent populations
should develop specific strategies focussing on the importance of daily breakfast consumption, increasing sports participation and decreasing TV viewing and computer use.

**Are EBRBs mediating variables in the associations between ethnic background and children’s body composition?**

Chapter 3 assessed the potential mediating role of specific EBRBs in the association between ethnic background and body composition in the Greek and Dutch subsamples of the ENERGY-study, where significant differences in body composition according to ethnic background were found. Partial mediation was found for sugared drinks consumption, sports participation and sleep duration in the Greek sample, and breakfast skipping in the Dutch sample. After adjusting the models for parental education, the mediating pathways were not statistically significant any more. Therefore, more studies are needed to disentangle which variables are able to further explain the ethnic differences in children’s body composition.

**Part Two:**

**Associations between parental education and children’s EBRBs**

**How do EBRBs cluster in European children and is there an association with parental education?**

Chapter 4 explored the clustering of several EBRBs in European children and its distribution by BMI status and assessed its association with parental education. Clusters characterized by lower activity levels and higher sugared drinks consumption were more prevalent in overweight and obese children. Children with lower educated parents were more likely to present unhealthier EBRBs clustering, characterized by higher sugared drinks intake, higher screen time and lower physical activity. The results highlight the importance of specifically focusing on lower educated parents and their children in order to develop effective primary prevention strategies.

**Is parental education independently associated with parental physical activity and children’s physical activity?**

Chapter 5 examined the independent associations of parental education and
parental physical activity with children’s physical activity levels. The results showed that parental education was associated with children’s physical activity in Greek and Spanish girls and Norwegian boys. Parental physical activity appeared to be associated with children’s physical activity in more than half of the participating countries. These results suggest that parental education and parental physical activity are independent factors associated with children’s physical activity, although the results were gender- and country-specific. The results suggest that intervention strategies focusing on increasing children’s physical activity levels should take into account the importance of parental physical activity levels.

Are parental sports participation and TV time mediating variables in the associations between parental education and children’s sports participation and TV time?
Chapter 6 assessed whether differences in two specific physical activity (i.e. sports participation) and sedentary (i.e. TV time) behaviours according to parental education were mediated by parental sports participation and TV time. Partial mediation of parental TV time of the association between parental education and children’s TV time was found in all countries, in which significant associations were present (i.e. Greece, Hungary, the Netherlands and Slovenia). Parental education differences in children’s sports participation were found in four countries (i.e. Greece, Hungary, Norway and Spain), but these differences were partially mediated only in Greece and Norway. Child reports on parental behaviour appeared to be more relevant than parents’ self-reports as correlates of children’s own sports and TV time, but parental self-reported behaviours appears to be more relevant for explaining parental educational differences in children’s TV and sports time. These results further suggest that strategies aiming to reduce children’s TV time and to increase sports participation should therefore take into account the role of parental modelling.

REFLECTION ON THE RESULTS

Mediating role of children’s EBRBs in the associations between socio-economic determinants and children’s body composition
European children from lower socio-economic families bear a disproportionate share of the burden of overweight and obesity compared to their better off counterparts (1, 2).
In this thesis, it has been shown that parental education, as an indicator of socio-economic position, was associated with children's body composition and that this association was partially mediated by certain EBRBs, namely breakfast consumption, sports participation, TV viewing and computer use (chapter 2). Recent reports have shown associations between positive energy balance, higher energy intake and lower energy expenditure and socio-economic affluence (3, 4). Lower socio-economic groups in industrialized countries and higher socioeconomic groups in developing countries tend to be at higher risk of obesity, although this relationship varies with gender, age and country (2). The results presented in this thesis show a significant role of several EBRBs in the explanation of the associations between parental education and children's body composition. However, the results suggest that other variables not included in the analyses (e.g. behavioural, environmental, parenting practices) may help to further explain this relationship.

The results pertaining those countries where ethnic differences in overweight status were present showed partial mediation for only few EBRBs, namely sugared drinks consumption and sleep duration in the Greek sample and breakfast consumption in the Dutch sample (Chapter 3). These results are in line with previous studies reporting associations of skipping breakfast and short sleep duration with a less favourable body composition in children and adolescents (5, 6). Nevertheless, the present results go further, showing significant mediation effect of these behaviours in the association between ethnic background and body composition. Previous reports on ethnic differences in childhood overweight and obesity showed higher BMI in non-native children compared to native children (7-9). Unlike in the Netherlands and most previous reports, Greek native children presented higher BMI and waist circumference (WC) compared to non-natives. These results reflect the fact that overweight rates among Greek children are among the highest of the world (10), and therefore children with other ethnic backgrounds are likely to have lower overweight prevalence. When adjusting the models for parental education, none of the behaviours remained significant as mediators, confirming the close relationship between ethnicity and parental education. Once again, the proportion of the associations explained by the identified mediators was relatively low, indicating the existence of other relevant mediators. Nevertheless, although cultural differences in health-related behaviours and lifestyles are major contributors to ethnic differences in obesity prevalence (7), it is likely that genetic background also contributes to racial disparities (11) and therefore should be taken into account for
the explanation of ethnic differences in childhood obesity.

** Associations between parental education and children’s EBRBs **
Children from lower socio-economic families not only present higher prevalence of overweight and obesity, but also unhealthier levels of EBRBs. The results of this thesis (chapter 4) show differences in EBRBs cluster distribution according to parental education level. Patterns characterized by low physical activity, high sedentary time and high sugared drinks consumption were more prevalent in children from lower educated parents, while healthier patterns characterized by high physical activity levels were more prevalent in children from higher educated parents. As other recent studies (12, 13), our results show clusters that cannot be seen as completely “healthy” or “unhealthy” patterns, as they are mainly characterized by only one or two marked behaviours. Nevertheless, the “unhealthier” clusters were more prevalent in children from lower educated parents.

The less favourable behavioural patterns in children from lower educated parents may be caused –at least to a certain extent- by the influence of parental modelling (14, 15). In agreement with previous studies (16, 17) this thesis provides evidence for the associations of parental physical activity and children’s physical activity (chapter 5) and the positive influence of parental education on children’s physical activity. Chapter 6 explored whether parental TV time and sports participation could explain parental education differences in children’s TV and sports participation. The results indicate that parent’s model behaviour may be one factor explaining why children from lower educated parents are more likely to engage in less healthy behaviours. In agreement with previous reports (14), the evidence for parental modelling regarding TV time was higher compared to parental modelling regarding sports participation. The results (chapter 5 and 6) suggest that parental influence on children’s sports participation is less likely to work through modelling compared to parental influence on children’s TV time. Parent and child TV viewing seem to be closely related and therefore strategies aiming to reduce children’s TV time may benefit from also targeting parental TV time. The evidence of partial mediation (or no evidence for mediation in some countries) indicates that parental modelling would certainly not be the only factor to be taken into account. In addition, we were not able to accurately measure parental modelling, which could also explain the partial mediation.
METHODOLOGICAL CONSIDERATIONS

The studies presented in this thesis are based on a cross-sectional study of the ENERGY-project. Methodological considerations, directly related to the specific studies are addressed in the discussion sections of the corresponding chapters. In this section, some general important methodological issues are discussed.

Design
The ENERGY-project cross-sectional survey included data on anthropometrics, several EBRBs and their potential determinants at the personal, school environment and family environment levels among 10 to 12 years old children in seven European countries. The study provides a unique data set of participants from different regions in Europe including some countries lacking data on EBRBs and potential correlates. The obtained data allow assessing differences of EBRBs and their correlates between diverse European regions and countries. However, some weaknesses characteristic of cross-sectional studies should be taken into account. First, the data allowed exploration of correlates of EBRBs and overweight and obesity. However, no causal inferences could be made because of the cross-sectional nature of the data. Second, there were some variations in response rates between countries, both at the school, child and parent levels. These differences may have limited the validity of cross-country comparisons.

Population selection bias
Obtaining a representative sample of the target population is of importance for the generalizability of the results to the source populations (i.e. European preadolescents). The best scenario would be to have the full list of eligible subjects and to perform a random sampling with every subject standing an equal chance of being included. However, participation in the ENERGY-project was on a voluntary basis, and therefore the following concerns should be taken into account.

Country representativeness of the samples
The cross-sectional study of the ENERGY project did not provide a national representative sample of all participating countries. National representation was aimed for in Greece, Hungary, the Netherlands and Slovenia, but not in Belgium, Norway and Spain. In the last three countries, samples were recruited only in specific regions and are therefore not representative for the country at large. These variations in sampling between countries may reduce the validity of cross-country
comparisons. However, the main results of the studies included in this thesis point in the same direction throughout the different countries, reflecting common trends across Europe.

**Representativeness of the child samples**

There were differences in response rates at school and individual level, affecting the external validity of the findings. The recruitment of schools in the Netherlands was especially difficult, probably due to the existence of many other health research programs involving recruitment of this target population. Families or schools having an interest in health may be keen to participate, while schools in deprived areas may have been underrepresented, resulting in an underestimation of prevalence rates. Although the results of the Dutch subsample are in line with existing data on overweight and obesity and obesogenic factors in this age group (18), these results should be interpreted with special caution. Some countries also showed lower response rates at the child level (i.e. Hungary, Norway and Spain). The main reason was because parents did not provide active parental informed consent. This may increase the participation of children from parents concerned about obesity prevention, resulting in underestimated prevalence results in those countries.

**Representativeness of the parent samples**

Parental response rate was lower compared to children’s response rate. If the non-response among parents was selective, the results obtained would not be representative for all eligible participants in the ENERGY-project. As parental education and ethnic background were reported by parental questionnaire, the low parental response rate could represent a problem in the studies included in this thesis. It was possible to study whether children with parents that did not provide us with the questionnaires differed from children with parents that filled in the questionnaire regarding certain characteristics such as anthropometric variables, age and gender. Results of these analyses showed that children with parents who did not fill in the questionnaire had smaller waist circumference and were more likely to be boys, but did not differ in BMI. Immigrant parents based on language spoken at home were less likely to fill in the questionnaire (OR: 0.47; 95%CI: 0.39; 0.58). These findings have to be taken into account when interpreting the results, as ethnic minorities may be underrepresented, and therefore the results pertaining prevalence rates in these groups may be also underestimated.
MEASUREMENTS

All measurements in the ENERGY project were obtained according to standardized protocols, and were conducted by trained personnel in all participating countries (19). All questionnaires were pre-tested among small samples in all participating countries to examine comprehensibility and duration of completion. Based on the results, the country specific and original versions were adapted when necessary, and the questionnaires were subsequently tested for validity and reliability (20, 21).

Anthropometric measurements
Body height, weight and waist circumference were measured by trained researchers or research assistants following a standardized protocol in all centres (19). Two readings of each measurement were obtained to assure accuracy. If the two readings differed more than 1% then a third measurement was taken. During the ENERGY-project meetings for researchers, at least one researcher per participating country was trained for the anthropometric measures. Intra-rater reliability rates ranged from 0.999 to 1.00 for weight and height measurements, and 0.942 to 0.999 for waist circumference measurements. The inter-rater reliability was 1.00 for weight and height measurements and 0.990 for waist circumference measurements(19). The quality of the anthropometric measures in the study sample is one of the major strengths, since self-reported weight is often heavily biased by misreporting, especially in overweight and obese children and adolescents (22-24).

Energy Balance-Related Behaviours (EBRBs)
Data on EBRBs were retrieved by means of child/parental self-reported questionnaires. The selection of EBRBs and correlates was based on the results of the literature reviews and secondary data analyses conducted in earlier studies of the ENERGY project (25). The ENERGY questionnaires were developed based on previous existing validated European questionnaires for most part of the questionnaires. If no such information was available in previous questionnaires, new items or questionnaire parts were constructed. First, original questionnaires were developed in English, and translated into the language of each participating country. Then, child and parent questionnaires were back translated in order to detect any potential differences between the two. In case of differences, adaptations were made accordingly. These procedures lead to accurate country-specific versions of the questionnaires (19) (questionnaires available on http://projectenergy.eu).
Reliability and content validity were tested separately in all countries except Slovenia with 100 children and 50 parents approximately per country for the reliability study and 15 children and 20 parents for the construct validity study. Test-retest reliability was assessed by comparing data from two completions of the questionnaire conducted one week apart, under equal circumstances (20, 21). Construct validity was determined via the degree of agreement between the questionnaire and information from cognitive interviews administered after completion of the first questionnaire (20, 21).

Self-reports on EBRBs are susceptible to bias. First, they may be affected by social desirability and recall bias, especially in overweight and obese subjects (26, 27). In addition, children completed the questionnaires in a maximum of one school hour, and therefore the number of items that can be included in the questionnaire was restricted (25). As a consequence, some of the assessed variables were measured with few or even single-item measures, and thus possibly reducing reliability and increasing measurement error. However, the questionnaires showed good test-retest reliability and moderate to good construct validity for the large majority of items (20, 21).

**Socio-demographic indicators of inequalities**

Two basic approaches to the study of associations between SES and health outcomes are the compositional approach and the contextual approach (28). Compositional measures of SES refer to characteristics of the individual (education, occupation, income), while contextual measures refer to characteristics of the individual’s environment (neighbourhood characteristics, regions). The studies included in this thesis have focused on parental education as an indicator of SES. Previous reports have shown consistent associations between parental education and childhood overweight (29, 30) and children’s EBRBs (14, 31-34). The rationale behind this use of parental education as the indicator of SES lies in the assumption that parental education can reflect other characteristics not related with economic wealth, like health-related knowledge (35) and problem solving skills (36, 37). Nevertheless, there are some considerations that should be taken into account:

First, we used a dichotomous variable reflecting children with at least one parent with more than 14 years of education (high) and children with both parents with less than 14 years of education (low), which reduced the variability in parental education, and made looking at the gradient of education and its association with
the studied outcomes no longer possible. Previous reports on associations between parental education and children’s health outcomes mostly included at least three educational categories, namely low, medium and high. After preliminary analyses of our data however, it was concluded that categorizing into low, medium and high education was not appropriate due to differences in education systems across the participating countries and the small sample size included in the low category.

Second, using a single SES indicator does not capture all angles of socio-economic inequalities. Each indicator (i.e. parental education, parental occupation, household income) may be measuring different aspects of SES, and therefore these indicators are not interchangeable (38). In addition, different SES factors could affect health at different times in the life course (39), operating at different levels and through different pathways (e.g. exposure, knowledge, attitudes) (40). On this regard, parental education seems to be a relevant factor to explain childhood overweight inequalities, as indicated by previous studies reported in the international scientific literature (29). However, other SES factors may help to further explain overweight inequalities. For children, it is important to consider, when possible, community-level SES indicators, because there is evidence that neighbourhood of residence is associated with overweight and obesity outcomes even when more individual or family-related SES factors like household income and parental education are controlled for (41-43).

Regarding ethnic background, the two indicators taken into account (i.e. country of birth of the parents and language spoken at home) are very “crude” ways of assessing ethnic origin of children, especially when considering them as dichotomous variables. Therefore, the complex and rich diversity in ethnic origins in the assessed countries is certainly not completely portrayed in the studies presented in this thesis. However, previous reports found similar trends across several European countries in ethnic weight status differences (44), indicating that something not directly related with the specific ethnicity, but with the “non-nativeness” in general, is associated with the more unfavourable patterns. On average, ethnic minorities in Europe and other affluent countries are often less well-off regarding general aspects as education, income levels and neighbourhood deprivation, and these generic socio-cultural factors, rather than, or on top of, specific cultural differences, may explain the unhealthier patterns (45, 46).
IMPLICATIONS AND RECOMMENDATIONS

Recommendations for future research

The present thesis is based on cross-sectional data, which allow assessment of associations but not predictive or causal relationships. There is need for longitudinal studies, including (natural) experiments that allow us to assess causal relations between socioeconomic determinants, EBRBs and the risk of childhood obesity. Besides longitudinal, also (natural) experimental research is obviously needed to determine causal relationships.

We were not able to make use of a complex measure of parental education, mainly due to the different educational systems within Europe. Using a dichotomized variable leads to less variability in the sample. Future studies may benefit from the inclusion of a more detailed measure of parental education level being able to elucidate more insight into the social gradient in overweight risk. According to the literature, different socioeconomic measures cannot be assumed to be interchangeable (47), and therefore the inclusion of multiple indicators (parental education, parental occupation, income) or composite measures or “indices” (48) may be beneficial in order to have a richer picture of inequalities and childhood obesity. In addition, the inclusion of contextual measures of SES (e.g. related to neighbourhoods) may allow better understanding inequalities in children’s overweight and EBRBs.

The assessment of ethnic differences can reflect unmeasured SES differences (49-51), and therefore further studies describing ethnic differences in EBRBs and childhood overweight are needed. In the present thesis, we did not assess whether specific subgroups of migrants presented higher risk of overweight compared to others. In a multicultural setting like Europe, in which migrant trends vary from one country to the other, the correct targeting of subgroups at higher risk of developing obesity and further knowledge about the specific determinants is a key objective in order to enable better tailored and targeted interventions for the groups most at risk.

The studies included in this thesis focused on a relatively small group of EBRBs. Although the behaviours were selected based on previous reports (52, 53) and reviews (54, 55) and therefore covered relevant behaviours related to childhood overweight, some improvements could be done in their assessment. Physical activity assessment via questionnaires has been shown to report smaller differences
between ethnic subgroups (56) and adolescents (57) compared to assessment by means of accelerometers, and therefore more advanced ways of physical activity measurement are preferred. In the cross-sectional ENERGY-study accelerometry was used for physical activity and sedentary behaviour measurement, but due to financial and practical constraints only in subsamples in some of the countries (58). In the cross-sectional ENERGY-study TV and computer time were assessed as the key sedentary behaviours. Nevertheless, these behaviours do not comprise total sedentary time (59), as other important activities, like studying or reading, were not covered. Future studies should therefore include a wider range of sedentary activities.

Implications for practice
The results of the studies included in this thesis suggest that some of the EBRBs were partially mediating the association between parental education / ethnic background and children's body composition, with higher overweight prevalence in children from lower educated parents and those from ethnic minorities. These results reflect the need for tailored obesity intervention strategies especially focusing on children from lower socioeconomic groups and the EBRBs that explained the observed differences in overweight prevalence. According to the principles of a planned approach of health promotion, it is important to know more about the explanation of the observed inequalities. The results (chapter 6) also show the importance of parental behaviours in children's behaviours. Therefore, changing parental EBRBs should very probably be included in childhood obesity prevention strategies addressing socioeconomic inequalities.
CONCLUSIONS

The results presented in this thesis first suggest that some important EBRBs, i.e. sugared-sweetened drinks intake, breakfast skipping, sports engagement, TV and computer time, in European children aged 10 to 12 are partially mediating the associations between parental education / ethnicity and children's body composition. The results also indicate that children with lower educated parents tend to have unhealthier combinations of EBRBs. Therefore, strategies aiming to reduce socio-economic inequalities in childhood overweight and obesity should focus on these important EBRBs. Finally, the results also stress the association of some parental EBRBs and children’s EBRBs (namely TV time and sports participation) and the mediating effect of those behaviours in the association between parental education and children’s behaviours.
References
Health 2011;11:328.
24. Elgar FJ, Roberts C, Tudor-Smith C, Moore L. Validity of self-reported
SUMMARY

Childhood overweight is one of the most serious public health challenges of the 21st century with increasing global prevalence in the last decades at an alarming rate. Even if some individuals are more genetically susceptible to gain weight, there is a consensus that the fundamental causes of the childhood overweight and obesity epidemic are the changes in lifestyle behaviours causing a positive imbalance between energy intake and energy expenditure. In order to address more specific goals for overweight and obesity prevention among school-aged children, it is necessary to differentiate the most relevant energy balance-related behaviours (EBRBs) in this age group. In addition, the prevalence of overweight and obesity is considerably higher among youth from lower socio-economic backgrounds and thus likely to augment broader social health inequalities. Recent studies also reported differences in childhood overweight and obesity prevalence and EBRBs levels according to ethnicity. Understanding the influence of socio-economic and ethnic variables on the EBRBs patterns leading to obesity is critical to developing effective public policies and interventions to prevent childhood overweight and obesity. The work presented in this thesis, as described in Chapter 1, aims to gain insight into the role of several EBRBs (i.e. sugared-sweetened drinks, breakfast skipping, active transportation to school, sports engagement, TV and computer time and sleep duration) that may explain parental educational and ethnic inequalities in childhood overweight in school-aged children across different countries in Europe.

To address the main aim of this thesis the following research questions were formulated:

1. Regarding the mediating role of children’s EBRBs in the associations between socioeconomic variables and children’s body composition (part 1):
   
a) Are EBRBs mediating variables in the associations between parental education and children’s body composition?
   b) Are EBRBs mediating variables in the associations between ethnic background and body composition?

2. Regarding the associations between parental education and children’s EBRBs (part 2):

   ...
a) How do EBRBs cluster in European children and is there an association with parental education?
b) Is parental education independently associated with parental physical activity and children’s physical activity?
c) Are parental sports participation and TV time mediating variables in the associations between parental education and children’s sports participation and TV time?

The work conducted for this thesis is part of a larger research project – i.e. the cross-sectional study of the “EuropeaN Energy balance Research to prevent excessive weight Gain among Youth” (ENERGY)-project. The cross-sectional study was carried out between March and July 2010 in Belgium, Greece, Hungary, the Netherlands, Norway, Slovenia and Spain, among pupils in the final years of primary education (aged 10-12). The general aim of the cross-sectional study was to provide up to date information on the prevalence of overweight and obesity, on the most important EBRBs and their personal as well as socio-cultural, physical and economic environmental determinants.

The first part of the thesis (chapters 2 and 3) focuses on the mediating role of children’s EBRBs in the associations between socioeconomic determinants and children’s body composition. Chapter 2 explored if several EBRBs could help to explain differences in children’s body composition according to parental education (question 1a). Sugared-sweetened drinks intake, breakfast skipping, sports participation, TV time and computer time partially mediated the association between parental education and children’s body composition, while no mediation effect was found for active transportation to school and usual sleep duration. The results of this study thus suggest that tailored overweight and obesity prevention strategies in low SES pre-adolescent populations should develop specific strategies focussing on the importance of daily breakfast consumption, increasing sports participation and decreasing TV viewing and computer use.

Chapter 3 assessed the potential mediating role of specific EBRBs in the association between ethnic background and body composition in the Greek and Dutch subsamples of the ENERGY-study, where significant differences in body composition according to ethnic background were found (question 1b). Partial mediation was found for sugared drinks consumption, sports participation and
sleep duration in the Greek sample, and breakfast skipping in the Dutch sample. After adjusting the models for parental education, the mediating pathways were not statistically significant any more. Therefore, more studies are needed to disentangle which variables are able to further explain the ethnic differences in children’s body composition.

Chapter 4 explored the clustering of several EBRBs in European children and its distribution by BMI status and assessed its association with parental education (question 2a). Clusters characterized by lower activity levels and higher sugared drinks consumption were more prevalent in overweight and obese children. Children with lower educated parents were more likely to present unhealthier EBRBs clustering, characterized by higher sugared drinks intake, higher screen time and lower physical activity. The results highlight the importance of specifically focusing on lower educated parents and their children in order to develop effective primary prevention strategies.

Chapter 5 examined the independent associations of parental education and parental physical activity with children’s physical activity levels (question 2b). The results showed that parental education was associated with children’s physical activity in Greek and Spanish girls and Norwegian boys. Parental physical activity appeared to be associated with children’s physical activity in more than half of the participating countries. These results suggest that parental education and parental physical activity are independent factors associated with children’s physical activity, although the results were gender- and country-specific.

Chapter 6 assessed whether differences in two specific physical activity (i.e. sports participation) and sedentary (i.e. TV time) behaviours according to parental education were mediated by parental sports participation and TV time (question 2c). Parental TV time partially mediated the association between parental education and children’s TV time in all countries, in which significant associations were present (i.e. Greece, Hungary, the Netherlands, Slovenia). Parental education differences in children’s sports participation were found in four countries (i.e. Greece, Hungary, Norway and Spain), but these differences were partially mediated only in Greece and Norway. Child reports on parental behaviour appeared to be more relevant than parents’ self-reports as correlates of children’s own sports and TV time, but parental self-reported behaviours appear to be more relevant for explaining parental educational differences in children’s TV and sports time.
Finally, chapter 7 summarizes the main findings of this thesis, critically discusses theoretical and methodological issues derived from this thesis and ends with the main conclusions and implications for further research and public health.

The studies described in this thesis have led to the following main conclusions:

First, the results suggest that some important EBRBs, i.e. sugared-sweetened drinks intake, breakfast skipping, sports engagement, TV and computer time, in European children aged 10 to 12 are partially mediating the associations between parental education / ethnicity and children's body composition. Second, the results also indicate that children with lower educated parents tend to have unhealthier combinations of EBRBs. Therefore, strategies aiming to reduce socio-economic inequalities in childhood overweight and obesity should focus on these important EBRBs. Finally, the results also stress the association of some parental EBRBs and children's EBRBs (namely TV time and sports participation) and the mediating effect of those behaviours in the association between parental education and children's behaviours.
SAMENVATTING

Overgewicht bij kinderen is één van de belangrijkste volksgezondheidsproblemen van deze eeuw. Ondanks dat sommige kinderen meer aanleg hebben om overgewicht te ontwikkelen, kan de toename in het vóórkomen van overgewicht bij kinderen niet door erfelijke invloeden worden verklaard. De toename wordt met name veroorzaakt door veranderingen in leefstijl die leiden tot te veel eten en te weinig bewegen, en dus een te hoge energiebalans. Om te voorkómen dat kinderen overgewicht ontwikkelen, moeten preventie programma’s zich richten op de belangrijkste gedragingen die hierbij een rol spelen. Daarbij moeten we ook in acht nemen dat overgewicht vaker voorkomt bij kinderen uit gezinnen met een lagere sociaaleconomische positie. Tevens blijkt dat bij Europese 10-12 jarigen het vóórkomen van overgewicht en de daaraan gerelateerde gedragingen, zoals het overslaan van het ontbijt, hoge frisdrank consumptie, te weinig bewegen, en veel TV kijken, verschillen tussen kinderen van hoger en lager opgeleide ouders en kinderen met en zonder immigratieachtergrond. Inzicht in hoe sociaaleconomische en immigratieachtergronden gerelateerd zijn aan overgewicht en de daaraan gerelateerde gedragingen is noodzakelijk voor het ontwikkelen van effectieve interventieprogramma’s en beleid.

Met dit proefschrift wordt bijgedragen aan de beantwoording van de volgende vraagstellingen, gebruik makend van gegevens die zijn verzameld bij 10-12-jarigen en hun ouders in zeven landen in Europa:

1- Kunnen verschillen in overgewicht gerelateerde gedragingen de verschillen in overgewicht tussen kinderen van hoger en lager opgeleide ouders verklaren?

2- Kunnen verschillen in overgewicht gerelateerde gedragingen de verschillen in overgewicht tussen kinderen met en zonder een immigratieachtergrond verklaren?

3- Welke combinaties van verschillende overgewicht gerelateerde gedragingen hebben Europese kinderen en hoe zijn bepaalde combinaties gerelateerd aan het opleidingsniveau van de ouders?

4- Is het opleidingsniveau van ouders gerelateerd aan de mate van lichamelijke activiteit van de ouders en aan de mate van lichamelijke activiteit van de kinderen?
5 - Kunnen sportdeelname en TV tijd van ouders het verschil in sportdeelname en TV tijd van kinderen van hoger en lager opgeleide ouders verklaren?

Het onderzoek gepresenteerd in dit proefschrift is onderdeel van een groter Europees project: “EuropeaN Energy balance Research to prevent excessive weight Gain among Youth” (ENERGY)-project. In zeven landen, België, Griekenland, Hongarije, Nederland, Noorwegen, Slovenië, en Spanje, hebben 10-12-jarigen en hun ouders vragenlijsten ingevuld over factoren die gerelateerd kunnen zijn aan overgewicht en enkele daaraan gerelateerde gedragingen, namelijk ontbijten, frisdrank consumptie, sport deelname en TV kijken. Tevens is bij deze kinderen hun lengte, gewicht en middelomtrek gemeten.

Het eerste deel van dit proefschrift (hoofdstukken 2 en 3) verkent in hoeverre verschillen in ontbijten, frisdrankconsumptie, sport deelname, TV kijken, actief transport naar school en slapen de verschillen kunnen verklaren in overgewicht tussen kinderen van lager en hoger opgeleide ouders en tussen kinderen met en zonder immigrantenachtergrond. Het bleek dat frisdrankconsumptie, het overslaan van het ontbijt, sportdeelname, TV en computertijd significant samenhangen met het verschil in overgewicht tussen kinderen van lager en hoger opgeleide ouders. Slaapduur en lopend of fietsend naar school gaan waren niet significant gerelateerd aan dit verschil in overgewicht. Deze resultaten suggereren dat interventieprogramma’s voor kinderen van lager opgeleide ouders zouden vooral gericht moeten zijn op het stimuleren van dagelijks ontbijten, sport deelname, beperkte/geen frisdrank innname, en beperking van TV en computertijd.

Hoofdstuk 3 richt zich op het verschil in overgewicht tussen Nederlandse en Griekse kinderen met en zonder een immigratieachtergrond. Deze studie laat zien dat dit verschil in overgewicht deels verklaard kon worden door verschillen in frisdrankconsumptie, sportdeelname en slaapduur (bij de Griekse kinderen) en het overslaan van het ontbijt (bij Nederlandse kinderen).

Hoofdstuk 4 laat zien dat lage lichamelijke activiteit in combinatie met hoge frisdrankconsumptie vaker voorkomt bij kinderen met overgewicht of obesitas. Bij kinderen van ouders met een lagere opleiding werd vaker een combinatie van ongezonde gedragingen gezien. Dit laat zien dat het belangrijk is om op meerdere gedragingen te richten bij interventies voor kinderen van lager opgeleide ouders.
In Hoofdstuk 5 bleek dat het het niveau van lichamelijke activiteit van de ouders was gerelateerd aan de mate van lichamelijke activiteit van de kinderen in meer dan de helft van de deelnemende landen. Daarnaast bleek het opleidingsniveau van de ouders alleen gerelateerd aan de mate van lichamelijke activiteit van Griekse en Spaanse meisjes en Noorse jongens.

Hoofdstuk 6 liet zien dat hoeveel ouders TV kijken deels kan verklaren waarom kinderen van lager opgeleide ouders meer TV kijken dan van hoger opgeleide ouders. Dit gold voor Griekenland, Hongarije, Nederland en Slovenië. Kinderen van lager opgeleide ouders doen minder aan sport dan kinderen van hoger opgeleide ouders in Griekenland, Hongarije, Noorwegen en Spanje. Deze verschillen konden alleen in Griekenland en Noorwegen deels verklaard worden uit de lagere sportdeelname van de ouders zelf.

In Hoofdstuk 7 worden de belangrijkste bevindingen samengevat en bediscussieerd. Uiteindelijk worden de belangrijkste conclusies en implicaties voor verder onderzoek en volksgezondheid geformuleerd.

De belangrijkste conclusies van dit proefschrift zijn:

Ten eerste, dat frisdrankconsumptie, het overslaan van het ontbijt, sport deelname, TV en computertijd bij Europese 10-12 jarigen bij lijken te dragen aan het het verschil in overgewicht tussen kinderen van lager en hoger opgeleide ouders, en tussen kinderen met en zonder een immigrantenachtergrond.

Ten tweede, dat bij kinderen van lager opgeleide ouders een combinatie van ongunstige gedragingen vaker voorkomt dan bij kinderen van hoger opgeleide ouders en dat interventieprogramma’s zich op deze combinaties van gedragingen moeten richten om gezondheidsverschillen naar opleiding en etniciteit te verkleinen.

Ten laatste lieten de resultaten zien dat gedrag van de ouders zelf, zoals TV kijken en sport deelname, gerelateerd is aan het gedrag van hun kinderen en daarmee ook verschillen in de gedragingen tussen kinderen van lager en hoger opgeleide ouders kan verklaren.
RESUMEN

El sobrepeso infantil se encuentra entre los problemas de salud pública más serios del siglo XXI, mostrando un alarmante aumento de su prevalencia a nivel global en las últimas décadas. Aunque ciertamente hay individuos que muestran mayor susceptibilidad genética a ganar peso, existe un consenso general en atribuir el origen fundamental de la epidemia de obesidad infantil a los cambios en los estilos de vida. Dichos cambios provocan un desequilibrio energético positivo entre la ingesta energética y el gasto calórico. Para poder prevenir el sobrepeso y la obesidad infantil de manera específica, es necesario determinar los comportamientos relacionados con el balance energético (CRBE) más relevantes en edad escolar. Por otro lado la prevalencia de sobrepeso y obesidad infantil es considerablemente mayor en niños y adolescentes de bajo nivel socioeconómico, aumentando así las desigualdades de salud. Algunos estudios recientes muestran que existen además diferencias en la prevalencia de sobrepeso y obesidad infantil según el lugar de nacimiento u origen étnico de la familia. Resulta clave por tanto entender cómo influyen las variables socioeconómicas y étnicas en los principales CRBE relacionados con la obesidad infantil a la hora de desarrollar programas de salud pública efectivos. El trabajo presentado en esta tesis, tal y como se describe en el Capítulo 1, tiene como objetivo profundizar en el conocimiento del papel que ejerce un grupo fundamental de CRBE (consumo de bebidas azucaradas-edulcoradas, hábitos de desayuno, transporte activo al colegio, práctica deportiva, uso de televisión y ordenador y duración del sueño), que pueden potencialmente explicar las desigualdades socioeconómicas (según el nivel educativo parental y lugar de origen), en la prevalencia de sobrepeso y obesidad en niños europeos de entre 10 y 12 años de edad.

Para abordar el objetivo principal de esta tesis se formularon las siguientes preguntas de investigación:
1. Acerca del papel mediador de los CRBE de los niños en la asociación entre variables socioeconómicas y su composición corporal (parte 1):
   a) ¿La asociación entre educación parental y composición corporal de los niños está mediada por los distintos CRBE?
   b) ¿La asociación entre lugar de origen y composición corporal de los niños está mediada por los distintos CRBE?

2. Acerca de la asociación entre educación parental y CRBE de los niños (parte 2):
a) ¿Cómo se agrupan los distintos CRBE en los niños europeos? ¿Existe asociación con la educación parental?
b) ¿Se asocia de manera independiente la educación parental con la actividad física de los padres y de los niños?
c) ¿Las asociaciones entre educación parental, práctica deportiva y consumo de televisión de los niños están mediadas por la práctica deportiva y consumo de televisión de los padres?

El trabajo llevado a cabo en esta tesis forma parte del estudio transversal del proyecto ENERGY (EuropeaN Energy balance Research to prevent excessive weight Gain among Youth). Dicho estudio transversal fue llevado a cabo entre Marzo y Julio de 2010 en Bélgica, Grecia, Hungría, Países Bajos, Noruega, Eslovenia y España, en niños de entre 10 y 12 años de edad. El objetivo general del estudio transversal fue actualizar la prevalencia de sobrepeso y obesidad, y recabar información sobre los CRBE más importantes y sus determinantes personales, socioculturales, económicos y ambientales en dicho grupo de edad.

La primera parte de la tesis (capítulos 2 y 3) se centró en el papel mediador de los CRBE de los niños en la asociación entre los determinantes socioeconómicos y su composición corporal. El Capítulo 2 exploró si los distintos CRBE de los niños podía ayudar a explicar las diferencias encontradas en su composición corporal según el nivel educativo parental (pregunta 1a). El consumo de bebidas azucaradas-edulcoradas, los hábitos de desayuno, la práctica deportiva y el uso de televisión y ordenador medieron parcialmente la asociación entre la educación parental y la composición corporal de los niños, mientras que no se encontró medición en el caso del transporte activo al colegio o la duración del sueño. Los resultados de este estudio sugieren por tanto que las estrategias encaminadas a la prevención del sobrepeso y obesidad infantil en grupos socioeconómicos desfavorecidos deberían centrarse en la importancia del desayuno, en incrementar la práctica deportiva y en reducir el tiempo total de uso de televisión y ordenador.

El Capítulo 3 valoró el papel potencialmente mediador de diversos CRBE en la asociación entre el lugar de origen y la composición corporal en las submuestras de Grecia y Países Bajos participantes en el estudio ENERGY (países en los que se encontraron diferencias significativas en la composición corporal de los niños según el lugar de origen, pregunta 1b). Se encontró mediación parcial en el caso de las bebidas azucaradas-edulcoradas, práctica deportiva y duración del sueño en la
muestra de Grecia, mientras que para la muestra de Países Bajos solamente los hábitos de desayuno mostraron mediación parcial. Tras ajustar los modelos por el nivel educativo parental, ninguno de los patrones de mediación fue significativo. En conclusión, es necesario continuar investigando para determinar qué variables son capaces de explicar en mayor medida las diferencias en la composición corporal de los niños según su lugar de origen.

El Capítulo 4 exploró el agrupamiento y distribución de los distintos CRBE en niños europeos según su Índice de Masa Corporal (IMC) y valoró la asociación de dicho agrupamiento y distribución con el nivel educativo parental (pregunta 2a). Los agrupamientos caracterizados por niveles bajos de actividad física y por un alto consumo de bebidas azucaradas-edulcoradas fueron más prevalentes en los niños con sobrepeso y obesidad. Los niños de padres con menor nivel educativo tuvieron mayor probabilidad de presentar agrupamientos de CRBE menos saludables, caracterizados por presentar alto consumo de bebidas azucaradas-edulcoradas, alto consumo de televisión y ordenador y bajo nivel de actividad física. Los resultados enfatizan la importancia de abordar específicamente a los padres con menor nivel educativo y a sus hijos a la hora de desarrollar estrategias de prevención primaria de la obesidad infantil.

El Capítulo 5 examinó la asociación de la educación parental y la actividad física de los padres con la actividad física de los niños de manera independiente (pregunta 2b). Los resultados mostraron una asociación significativa entre la educación parental y la actividad física de los niños en el caso de las chicas españolas y griegas y en el caso de los chicos noruegos. La actividad física parental estuvo asociada con la actividad física de los niños en más de la mitad de los países participantes. Estos resultados sugieren que el nivel de educación parental y la actividad física parental son factores independientes asociados con la actividad física de los niños, aunque los resultados fueron diferentes según país y género.

El Capítulo 6 valoró si las diferencias en la práctica deportiva y el consumo de televisión de los niños encontradas según el nivel educativo de los padres estaban mediadas por el modelado de los padres (pregunta 2c). El consumo de televisión parental presentó mediación parcial en todos los países en los que hubo asociaciones significativas entre el nivel educativo parental y el consumo de televisión de los niños (Grecia, Hungría, Países Bajos y Eslovenia). Se encontraron diferencias significativas en las asociaciones entre nivel educativo parental y la
práctica deportiva de los niños en cuatro países (Grecia, Hungría, Noruega y España), aunque dichas asociaciones estuvieron parcialmente mediadas por la práctica deportiva de los padres solamente en el caso de Grecia y Noruega. La percepción de los niños sobre el comportamiento de sus padres resultó más relevante que los autoinformes de los padres a la hora de explicar las diferencias en la práctica deportiva y consumo de televisión de los niños según el nivel educativo parental.

Finalmente, el capítulo 7 resume los hallazgos principales de la tesis, muestra las reflexiones teóricas y metodológicas derivadas de la misma y finaliza con las conclusiones principales y las posibles implicaciones para investigaciones futuras y para el ámbito de la salud pública.

Los estudios descritos en esta tesis han conducido a las siguientes conclusiones principales:

En primer lugar, los resultados sugieren que algunos de los CRBE más importantes en edad escolar (consumo de bebidas azucaradas-edulcoradas, hábitos de desayuno, práctica deportiva, consumo de televisión y ordenador) tienen un papel mediador en las asociaciones existentes entre el nivel educativo parental/lugar de origen y la composición corporal de los niños europeos de entre 10 y 12 años de edad. En segundo lugar, los resultados también indican que los niños de padres con menor nivel educativo presentan combinaciones menos saludables de dichos CRBE. Por todo ello, las estrategias encaminadas a reducir las desigualdades socioeconómicas en el sobrepeso y obesidad infantil deberían focalizarse en dichos CRBE. Finalmente, los resultados también recalan la asociación de algunos CRBE de los padres con los CRBE de sus hijos (consumo de televisión y práctica deportiva), y el efecto mediador que dichos comportamientos ejercen en la asociación entre el nivel educativo parental y los comportamientos de los niños.
ABBREVIATIONS
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ANOVA  Analysis of Variance
B  Beta (unstandardized regression coefficient)
BMI  Body mass index
CI  Confidence interval
ENERGY  EuropeaN Energy balance Research to prevent excessive weight Gain among Youth
EBRBs  Energy balance-related behaviours
ICCs  Intra-class correlation coefficients
IOTF  International Obesity Task Force
M  Mediator
MANOVA  Multivariate analysis of variance
N  Number of subjects
OR  Odds ratio
PA  Physical activity
PASW  Predictive Analytics SoftWare
PEL  Parental education level
SB  Sedentary behaviours
SD  Standard deviation
SE  Standard error
SES  Socio-economic status
SPSS  Statistical Package for the Social Sciences
TTPA  Total time of physical activity
WC  Waist circumference
X  Predictor
Y  Outcome
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Esta tesis está dedicada a mi abuela Felisa.
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