Lifestyle patterns in European preschoolers: Associations with socio-demographic factors and body mass index

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Running title

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Abstract

Background: Energy balance-related behaviors (EBRBs), i.e. dietary intake, screen, outdoor play and sleep, tend to combine into 'lifestyle patterns', with potential synergistic influences on health. To date, studies addressing this theme mainly focused on school children and rarely accounted for sleep, with a cross-country perspective.

Objectives: We aimed at comparing lifestyle patterns among preschool-aged children across Europe, their associations with socio-demographic factors and their links with body mass index (BMI).

Methods: Harmonized data on 2-5-year-olds participating in nine European birth cohorts from the EU Child Cohort Network were used (EBRBs, socio-demographics, anthropometrics). Principal component analysis, multivariable linear and logistic regressions were performed.

Results: The most consistent pattern identified across cohorts was defined by at least three of the following EBRBs: discretionary consumption, high screen time, low outdoor play time and low sleep duration. Consistently, children from low-income households and born to mothers with low education level had higher scores on this pattern compared to their socio-economically advantaged counterparts. Furthermore, it was associated with higher BMI z-scores in the Spanish and Italian cohorts (β=0.06, 95% CI=[0.02;0.10], both studies).

Conclusion: These findings may be valuable in informing early multi-behavioral interventions aimed at reducing social inequalities in health at a European scale.

Keywords: European birth and pregnancy cohorts; preschool children; socio-demographics, socio-economics; lifestyle patterns; nutrition transition, overweight

Abbreviations

ALSPAC: Avon Longitudinal Study of Parents and Children; BiB: Born in Bradford; BMI: body mass index; ECCN: EU Child Cohort Network; EBRBs: energy balance-related behaviors ; EDEN: Étude des Déterminants pré et postnatals du développement et de la santé de l'Enfant; ELFE: Etude Longitudinale Française depuis l'Enfance; INMA: INfancia y Medio Ambiente; MoBa: Norwegian Mother, Father and Child Cohort Study; NCDs: non-communicable diseases; NT: nutrition transition; PCA: principal component analysis; RHEA: Mother Child Cohort in Crete; SEP: socioeconomic position; SWS Southampton Women's Survey;

Introduction

Growing out of the forces of globalization and urbanization, profound upheavals have occurred worldwide during the 20th century. Since the 1960s, economic growth has been accompanied by stark changes in energy balance-related behaviors (EBRBs), though at different paces according to region [1]. On the one hand, the 'Westernization' of diet has especially resulted in the increase of energy-dense, nutrient-poor and ultra-processed foods. On the other hand, a change in movement behaviors is reflected in increased time spent in sedentary screen behavior, and reduced physical activity levels at work and during recreational time[2].

This lifestyle shift has been embedded into two other transitions, namely the demographic and the epidemiologic [3]. These have contributed to the increase in non-communicable diseases (NCDs), with overweight and obesity being recognized indicators of the 'negative' phase of the nutrition transition (NT) under way worldwide [3]. Young children represent one of the most vulnerable population groups with regards to long-term health consequences of obesity [4]. The NT has been conceptualized into five broad stages, (1) hunter-gatherer or Paleolithic, (2) modern agriculture and famine, (3) receding famine (as incomes grow), (4) nutrition-related chronic diseases or 'negative' stage, and (5) change toward more healthful behaviors [3]. Whereas high-income countries are, overall, further ahead in the NT compared with low- and middle-income countries, these shifts do not occur in a linear and uniform way between and within countries. Variations in the transition stages, or pace from one stage to another, can therefore be locally observed depending on various socio-economic, socio-demographic and socio-cultural factors[5]. Likewise, across Europe, a diverse picture of overweight and obesity prevalence among preschool children can be observed [6]. Although this has reached a plateau in some high-income countries [7], it still remains high and of concern because of its early socio-economic patterning [8] and adverse health and well-being consequences in the short and long term [4].

Whereas studies have mostly evaluated the independent association of each EBRB with body mass index (BMI), these behaviors were shown to combine into so-called 'lifestyle patterns', with a potential synergistic influence on health. Previous reviews have highlighted three types of lifestyle patterns: unhealthy, healthy and mixed (the latter combining both unhealthy and healthy EBRBs) [9–13]. In high-income countries, the unhealthy lifestyle patterns (consistently characterized by high consumption of discretionary food and high screen time worldwide) have most often been shown to be associated with increased risk of having overweight (albeit less consistently shown in cross-sectional studies) and inversely with socio-economic position (SEP) [9–13]. To date, studies that have taken up this theme mainly focused on school children and did not consider sleep, a movement behavior worth investigating when tackling overweight risk [11]. Furthermore, while this question was addressed at large geographical European scales [14,15], cross-European studies providing insights into country-specific EBRBs combinations are currently lacking, especially in preschoolers.

We therefore aimed to examine whether an unhealthy lifestyle pattern (and possibly others) emerged as early as preschool age across several European cohorts; and whether it was associated with not only BMI, but also other socio-demographic factors. We hypothesized that this unhealthy lifestyle pattern could represent another indicator of the established NT 'negative' phase at the European level, with expected nuances on the associations, as all the countries, and their population subgroups, have likely been experiencing different NT dynamics.

Materials and methods

Cohorts and participants - The EU Child Cohort Network

This study was conducted within the EU Child Cohort Network (ECCN), a sustainable network of birth cohort studies established to enable the identification of early-life stressors influencing cardio-metabolic, respiratory and mental developmental outcomes, and health trajectories, during the life course[16,17].

A cohort from the ECCN was eligible for inclusion in the present study if information was available on at least nine of the 11 EBRBs at preschool age being considered (refer to the *Measurements* section below). In total, we used data from nine cohort studies, established between 1990 (ALSPAC) and 2011 (ELFE, Piccolipiù): the Avon Longitudinal Study of Parents and Children (ALSPAC)[18,19], Born in Bradford (BiB)[20], and the Southampton Women's Survey (SWS)[21] in the UK; the Etude des Déterminants pré et postnatals du développement de la santé de l'Enfant (EDEN))[22] and Etude Longitudinale Francaise depuis l'Enfance (ELFE)[23] in France; the INfancia y Medio Ambiente (INMA)[24] in Spain; the Norwegian Mother, Father and Child Cohort Study (MoBa)[25] in Norway; the Piccolipiù cohort in Italy[26]; and the Mother Child Cohort in Crete, Greece (RHEA)[27]. More details about the cohorts are provided in **Supplementary material 1**.

Of the 165 824 children initially recruited in all cohorts, several participants were lost to follow-up, not followed-up (just a smaller subsample was followed-up with regards to EBRBs in BiB) or dropped out between enrolment and around 3 years of age (**Supplementary material 2**). Additionally, children with missing information on all EBRBs of interest were excluded, resulting in 89 857 (54.2%) eligible children for lifestyle pattern identification at around 3 years of age. An additional 13 529 (15.1%) children were excluded due to lack of socio-demographic information; and 25 164 (32.9%) children did not have necessary data for inclusion in analyses on BMI outcomes, resulting in a final sample size of 51 164 children. Of note, only a 10% sample of the ALSPAC cohort, known as the Children in Focus (CiF) group, attended clinics at the University of Bristol at various time intervals between 4 to

61 months of age. The CiF sample was chosen at random from the last 6 months of ALSPAC births occurring in 1992 (1432 families attended at least one clinic).

Measurements

Cohort-specific description about methods for ascertaining and defining variables are documented in the ECCN catalogue (https://data-catalogue.molgeniscloud.org/catalogue/catalogue/#/).

EBRBs

Information on children's EBRBs was measured via parental questionnaires at preschool age, on average around 3 years (range of 2 to 5; **Supplementary material 3**). If information was not available at 3 years, variables collected at 4 or 5 years were preferred to variables collected at 2 years of age, the focus having been placed on preschool age. We chose a set of EBRBs based on the literature[11,28,29] and their availability across cohorts.

Diet. Data from validated Food Frequency Questionnaires were used to define frequencies of consumption for various dietary items [30–36]. Harmonized variables were created in each cohort describing how many times the following food groups were consumed a day: vegetables (excluding potatoes), fruit, fish, discretionary savory foods, discretionary sweet foods, processed meat, and sweet beverages.

Screen time. Television watching (including videos and DVDs) was assessed as an indicator of screen time. Due to variability in birth year across cohorts and thus media landscapes, only three cohorts had data available for time spent watching other screens (BiB, ELFE, and Piccolipiù): computers for BiB; computers, smartphones, video games and tablets for ELFE; tablets and smartphones for Piccolipiù. The harmonized screen time variables (TV time and other screen time) were expressed in hours/day.

Physical activity. Outdoor play time (BiB, EDEN, ELFE, Piccolipiù, RHEA) or time spent outside (ALSPAC, MoBa and SWS) were assessed as an indicator of physical activity. Due to evidence suggesting seasonal variations in physical activity taking place outdoors [37], the daily time spent (playing) outdoors was

transformed to seasonal z-scores. Data on physical activity was unavailable for preschoolers in INMA and was only assessed at weekends for Piccolipiù.

Sleep duration. Total time spent sleeping per 24h (continuous, in hours) was obtained by summing night time sleep and nap durations. Data on naps were not available for INMA or MoBa.

Socio-demographic factors

Several maternal and household socio-demographic factors, as well as child sex, were hypothesized to be potential correlates of children's lifestyle patterns and/or BMI and were thus included in the association analyses[9–11,38]. Log-equivalized disposable household income in quintiles was measured using the Equivalized Household Income Indicator (EHII) [39]. Maternal factors included mother's age at her child's birth (in years), maternal education level defined according to the International Standard Classification of Education 97/2011 (High: Short cycle tertiary, Bachelor, Masters, Doctoral or equivalent; Medium: Upper secondary, Post-secondary non-tertiary; Low: No education, early childhood, pre-primary, primary, lower secondary or second stage of basic education) and parity (primiparity vs. multiparity). All socio-demographic factors were measured at birth.

BMI outcomes

Child weight and height were measured either by clinicians, research staff, or parental self-report (**Supplementary material 4**). We used the weight and height measurements collected as close as possible to the time of EBRBs' measurements i.e., between 2 and 5 years depending on the cohort (**Supplementary material 2)** +/- 6 months. Age and sex-specific BMI z-scores were generated using the WHO growth standards [40], and each child was classified as having 'overweight/obesity'', or not, using WHO BMI standards (+/-2 SD) [40].

Cohort-specific statistical analyses

Lifestyle patterns derivation

For each cohort, we used principal component analysis (PCA) to derive a smaller number of lifestyle patterns from the 11 available EBRB items. In a given cohort, children with missing data for all EBRBs were excluded (**Supplementary material 2**). Missing data for EBRBs ranged from 0.3% for the BiB sleep time variable to 62.8% for the MoBA sleep time variable (**Supplementary material 5**), thus we used the 'missMDA' package in R Software to impute missing values based on the correlations between EBRBs and similarities between children [41]. We determined the final number of principal components to retain using scree-plots, along with the criterion of eigenvalues above one [42]. Items with absolute values of the loadings >0.30 were considered to make a reasonable relative contribution to the principal components, and these were interpreted and labeled accordingly [43]. Each child had a score for each PCA-identified lifestyle pattern: a higher (lower) score representing a higher (lower) adherence to that pattern.

Association analyses

Complete-cases univariable and multivariable linear regression models were applied to assess the associations of socio-demographic factors with the lifestyle pattern scores, including: household income (EHII index), maternal education level, maternal age at delivery, parity, and child sex. The cross-sectional associations of lifestyle pattern scores with child BMI z-scores and having overweight were examined by a linear and logistic regression model. All models were first run unadjusted and then adjusted for the socio-demographic factors mentioned above, all known to be associated with children EBRBs and BMI.

All statistical analyses by cohort were conducted using R and R-based DataSHIELD platform. DataSHIELD is a data infrastructure with series of R packages, that enables a remote federated analysis, without the need of physically transferring, pooling, sharing, or disclosing the individual-level data across the cohorts participating in the LifeCycle consortium [44].

Results

Participant characteristics

The main characteristics of the studied populations are shown in **Table 1**. Children from the French (EDEN and ELFE), Norwegian (MoBa), and Italian (Piccolipiù) cohorts had the highest proportions of mothers having attained high levels of education, with 50% to 70% holding a Bachelor, Masters or Doctoral degree. The most common education level attained in the Spanish (INMA), Greek (RHEA), and English (SWS, ALSPAC) cohorts was secondary/vocational school with 40.7%, 50.5%, 59.7% and 69.1% of the mothers in this category, respectively. Noteworthy, the English BiB cohort - located in a more disadvantaged area – comprised 58.6% of mothers with low education levels. Most of the preschoolers' mothers were born in the cohort country (90%), except for BiB (60%).

At preschool age (from 2 to 5 years), the lowest percentage of children with overweight/obesity was observed in the French (EDEN and ELFE) cohorts (2.3% and 2.9% respectively), whereas the Spanish (INMA) and the Greek (RHEA) cohorts had the highest percentages (8.9% and 11.9%, respectively).

Lifestyle pattern identification

Two lifestyle patterns, accounting from 24.5% (for Piccolipiù) to 35.0% (for RHEA) of the total variance, were identified in each cohort (**Table 2**).The most consistent pattern was characterized by at least three of the following EBRBs in each cohort: suboptimal dietary intake (low intake of fruit and vegetables, high intake of discretionary savory and sweet snacks, processed meat, and sweet beverages), high TV and other screens time (where available), lower outdoor play time and lower sleep duration. This lifestyle pattern was thus labeled 'unhealthy'. Piccolipiù was the only cohort where this lifestyle pattern was entirely characterized by suboptimal movement behaviors but not dietary intake.

Relatively high fruit, vegetable, and fish intake, commonly characterized the second pattern in all cohorts. However, the other diet and movement behavior items loaded differently depending on the

cohorts. Thus, it was labelled 'healthy' (for ALSPAC, ELFE, INMA, Piccolipiù) or 'mixed' (for BiB, EDEN, MoBa, RHEA, SWS).

We thereafter focused, for the association analyses, on the unhealthy lifestyle pattern only.

Association analyses

In the multivariable models, household income and maternal education level were inversely associated with the unhealthy lifestyle pattern scores (**Tables 3a, 3b, 3c**), except for BiB (positive associations). Links between other socio-demographic factors and the unhealthy lifestyle pattern were not uniform across cohorts. In ALSPAC, ELFE, INMA, MoBa, and SWS, the younger the mothers at the time of delivery, the higher the unhealthy pattern scores were. In ALSPAC, ELFE, MoBa and SWS the scores were higher for children from multiparous mothers. Lastly, boys scored higher than girls in ALSPAC, EDEN, ELFE, and MoBa.

Cross-sectional relations between the unhealthy lifestyle pattern scores, BMI and overweight status also differed by cohort (**Table 4**). While in most of them no associations were apparent from the multivariable models, unhealthy lifestyle pattern scores were positively associated with both BMI z-scores (β=0.06, 95% CI: 0.02;0.10) and higher odds of having overweight/obesity (OR=1.28, 95% CI: 1.13;1.44) in the Spanish INMA cohort, and BMI z-scores in the Italian Piccolipiù cohort (β=0.06, 95% CI: 0.02;0.10). In BiB and MoBa, a weak inverse association was observed with BMI z-scores (respectively, β=-0.05 95% CI: -0.10;0.00 and β=-0.03, 95% CI: -0.04;-0.02).

Discussion

We identified two patterns of lifestyle behaviors in preschoolers in nine population-based European cohorts. One was labeled “unhealthy” and characterized by at least three of the following EBRBs: suboptimal dietary intake, high screen time, low outdoor play time, and low sleep duration. The other pattern was healthier given its characterization by high fruit, vegetables, and fish intake; however, it was not as consistent for other dietary items and movement behaviors, and so the pattern was considered either healthy or mixed depending on the cohort. Children from lower income households and those born to mothers with a lower education level, on the whole, tended to adhere more to the unhealthy pattern. Although the cohorts are set within different countries with different social, economic, and cultural landscapes, within each cohort analyses identified a distinctly identifiable ‘unhealthy’ lifestyle pattern. In addition, it was associated with similar socio-economic factors across the different cohorts with some differences in BiB cohort. Associations of this pattern with other socio-demographic characteristics, namely maternal age at delivery, parity and child sex, varied more between cohorts. Likewise, cross-sectional associations between the unhealthy lifestyle pattern and BMI differed, with positive relations only observed in the Spanish and Italian cohorts.

Lifestyle patterns, socio-demographic factors and BMI: an overview of the NT dynamics in Europe

The co-occurrence of unhealthy dietary intake, high consumption of sweet beverages, high screen time, low outdoor play time and/or sleep duration, along with the observed sex-specificity, have been described worldwide in different age groups in a number of pediatric studies [9–13,45,46]. Such an unhealthy lifestyle pattern could reflect the established ‘negative’ phase of the NT in Europe [47] given that for almost all cohorts included in this study, children from lower socio-economic backgrounds adhered more to it. Indeed, while in the early stages of NT, unhealthy lifestyle behaviors, obesity and non-communicable diseases affect individuals with higher SEP, the reverse has been observed when the NT is further developed [3]. The discordant findings in BiB may originate from the socio-cultural characteristics of this cohort population, as a large proportion of mothers originated from Pakistan, a

middle-income economy still at an early stage of its NT [48,49]. Migrants, when not yet acculturated to the obesogenic food environment, tend to value fresh, traditional, and unprocessed healthy foods, along with skills and strategies to buy and cook these, in spite of often living in disadvantaged contexts [50]. At a community level, some studies have found that living in neighborhoods with a high representation of ethnic minorities (as is the case in BiB) is associated with healthier diets [50]. Ultimately, other social factors not accounted for in this analysis may have confounded the observed associations. In this socio-demographic transitioning world, mothers are not only more mobile but also more involved in the labor force[5], thus affecting the time devoted to domestic tasks. Having more than one child may further hamper the quantity of time allocated per child [51]. This could influence their ability to adopt optimal eating- and movement behavior-related practices as reflected by the inverse associations between unhealthy lifestyle pattern score and multiparity that we highlighted in some cohorts [52].

Of note, as industrialization and economic development began at different dates and occurred at different pace in the various regions of Europe, so did the NT 'negative' phase. By the 1960s, most countries in Western Europe — save the Mediterranean area — had gone through this phase, and have, since then, initiated the final stage towards healthier behaviors of the NT [53]. This may partly explain why the positive association between unhealthy lifestyle patterns and having overweight was observed in the Spanish INMA and Italian Piccolipiù cohorts only. However, putting forward such a large-scale mechanism to explain these associations might not be sufficient, because it does not account for the heterogeneity across cohorts. Other proximal factors affect EBRBs and BMI, such as socio-economic inequalities. In the present study, setting BiB aside, INMA had the highest proportion of the least educated mothers (26.1%). Another explanation could be a longer cumulative effect of the adherence to the unhealthy lifestyle pattern in the Spanish and Italian cohorts, given that EBRBs were collected at around 4 years of age (versus 3 years in the others). It may be necessary for children to have prolonged exposure over time to potentially detrimental EBRBs for associations with outcomes such as BMI to become evident. Ultimately, a satisfying explanation for these results would probably

require the involvement of genetic, epigenetic and additional environmental factors and their mutual interactions.

In the present study, the combination into a rather healthier lifestyle pattern of 'Western' dietary items, alongside recommended foods and movement behaviors, could reflect an on-going shift into this ultimate 'behavioral change' phase from the NT theory[47]. This hypothesis is empirically supported by a recent review summarizing published research on NT patterns in European adult populations over the last three decades (1990–2020)[1]. However, among ethnic minorities that may be in their early transition (e.g. most mothers in BiB), emergence of such patterns could also mirror the switch towards the 'negative' phase where some sporadic aspects of the pre-transitional epoch persists [47].

Public health implications

Despite the growing evidence of both a switch toward the 'behavioral change' phase[1] and a plateauing of the prevalence of childhood overweight in most of European countries[7], the 'negative' NT stage does not seem to be restricted to the periods in which it first arose. It does continue to concern ethnic minorities and socio-economic disadvantaged population groups [5], with its potential subsequent short- and long-term consequences on obesity and non-communicable diseases. These social inequalities in lifestyle patterns and health at the European scale, as early as preschool age, call for early multi-behavioral interventions.

Most public health interventions aimed at modifying EBRBs are based on individual health behavior models centered on the individual agency [54]. In general, such models relegate to second place the economic, social and cultural environments in which people function and the embeddedness of their actions in larger ecological layers. Structural interventions that aim to foster the individual autonomy by changing the social determinants of health could be more successful in promoting widespread behavioral change and equity [55]. Notably, the consistent inverse associations of household income and maternal education level with the unhealthy lifestyle patterns highlighted in almost all countries indicate that family-based multi-behavioral interventions should be adapted to address the

various characteristics of socio-economic disadvantage. Such targeted and proportionate interventions should also consider other socio-demographics factors, such as children's sex, maternal age (at delivery) and parity. Finally, it is also of paramount importance to better understand how socio-cultural factors influence the development of children's EBRBs within families.

Certainly, all these above-mentioned points should be taken into consideration. However, for better policy development and coordination within countries, improvements should also be implemented at the European level, especially given the transboundary nature of many distal factors impacting EBRBs, but not studied here, for example the built environment or commercial determinants of health [1]. For example, modern food retailers sell inexpensive and highly processed food and beverage items and these are considered to be "more fashionable" than items sold the traditional food retail sector.

Limitations and strengths

This study is subject to several limitations and strengths. Much of the data were obtained by report from the principal caregivers, which may have introduced recall errors and social desirability bias. We also adjusted for a parsimonious set of confounders when investigating associations, but residual confounding could still be present, as reflected by the (borderline) inverse relations identified between unhealthy lifestyle pattern scores and BMI z-scores in BiB and MoBa. Of note, in the Norwegian (MoBa) cohort, children included in the analyses had their anthropometric data obtained before or at the same time as the collection of data for the lifestyle patterns; additionally, anthropometric data were self-reported in this cohort (**Supplementary material 4**). These two methodological characteristics may in part explain the reverse association highlighted between the unhealthy lifestyle pattern and BMI. In general, the cross-sectional nature of the analyses limits our capacity to draw temporal inferences from our findings. However, the relative stability of the studied socio-demographic factors makes the temporality chain more plausible (e.g. parental education level is relatively stable over time). Reflecting their high socio-economic position, the low proportion of EDEN and ELFE children who had

overweight might partly explain the null associations found in those cohorts between unhealthy lifestyle patterns and BMI. Although all levels of maternal education were represented in this study, samples were generally highly educated in some cohorts (especially, EDEN, ELFE, and MoBa). In addition, mothers excluded from the analyses tended to be less educated and younger (data not shown). Whereas these characteristics may have implications for generalizability of the findings, the lifestyle patterns derived here are rather consistent with other studies performed in school-aged children worldwide [9–13,45]. In the same vein, the consistent socio-economic unhealthy lifestyle pattern relations identified across cohorts support external validity. Finally, the harmonization within the ECCN was not perfect and certain constraints resulted in a loss of information and precision. Especially, not every EBRB was available in each cohort and the available socio-demographic variables did not necessarily capture the specificities of individual cohorts: for example, a non-negligible number of BiB participants were foreign-educated mothers and their qualifications were not always able to be captured. However, it is remarkable to see that we still obtained great consistency in the patterns, allowing us a broad and European vision of NT phenomena in young children. Indeed, the study populations were at a critical period regarding lifestyle EBRBs acquisition, thus offering interesting opportunities for promotion, prevention and intervention.

Conclusion

The identification of similar unhealthy lifestyle patterns, their socio-economic patterning and links to BMI as early as preschool age provides new evidence regarding the NT dynamic across different European high-income countries. This signals the urgent need for regional and context-specific policies to avert negative and costly consequences for health-care systems and societal well-being. Family-based policies and multi-behavioral interventions that consider the social settings may hold promise for promoting optimal EBRBs over the life course, and challenge one-size-fits-all approaches.

Declarations

Consent for publication

Written informed consent for publication was obtained from all participants in all cohorts. All authors consent to publication of the manuscript, figures, tables and supplementary material.

Competing interests

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Authors' contributions

PDM and SL conceived and designed this specific analysis. LC, MC and AD performed the statistical analysis under the supervision of PDM and SL. AD wrote the paper under the supervision of PDM and SL. LC, MC, BH, MAC, AE, DA, HI, JRH, JLTN, JW, JJ, KM, MVa, MVr, MS-P, SFB, SLl, SM, SB, TC, TR, TS, TY, PDM, SL were involved in preparation and provision of cohort data, interpreting the results and editing the manuscript for important intellectual content. All authors read and approved the final manuscript.

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Tables

Table 1. Characteristics of the study samples.

	ALSPAC, 1991 (n=10 595)	BiB, 2007 (n=1 168)	EDEN, 2003 (n=1 321)	ELFE, 2011 (n=11 623)	INMA, 2003 (n=1 584)	MoBa, 1999 (n=57 597)	Piccolipiù, 2011 (n=2 258)	RHEA, 2003 (n=1 086)	SWS, 1998 (n=2 625)
Household level									
Income (EUSILC-score, quintiles[1])									
First	1556 (17.2)	233 (21.3)	173 (13.6)	1398 (13.5)	236 (16.0)	8469 (16.6)	330 (15.5)	152 (16.7)	366 (19.7)
Second	1795 (19.8)	229 (20.9)	240 (18.9)	1989 (19.2)	295 (20.0)	9593 (18.8)	422 (19.8)	169 (18.6)	370 (20.0)
Third	1881 (20.7)	218 (19.9)	280 (22)	2225 (21.5)	302 (22.0)	10705 (21.0)	454 (21.4)	183 (20.2)	377 (20.3)
Fourth	1922 (21.2)	214 (19.5)	282 (22.1)	2317 (22.4)	297 (20.0)	10657 (20.9)	451 (21.2)	197 (21.7)	374 (20.2)
Fifth	1913 (21.1)	201 (18.4)	297 (23.3)	2414 (23.3)	324 (22.0)	11507 (22.6)	469 (22.1)	207 (22.8)	367 (19.8)
Missing data[2]	1528 (14.4)	73 (6.3)	49 (3.7)	1280 (11.0)	130 (8.2)	6666 (11.6)	132 (5.8)	178 (16.4)	771 (29.4)
Maternal factors									
Age at delivery									
Mean age	27.0 (5.8)	27.7 (5.6)	29.9 (4.7)	30.9 (4.7)	31.96 (4.1)	30.43 (4.4)	33.9 (4.8)	29.67 (4.6)	30.3 (3.8)
Missing data[2]	1365 (12.8)	0 (0.0)	0 (0.0)	47 (0.4)	7 (0.04)	83 (0.1)	0 (0.0)	16 (1.5)	0 (0.0)
Education level at inclusion[3]									
High	1440 (14.2)	284 (26.4)	786 (59.7)	7824 (67.3)	355 (23.0)	37778 (69.3)	1087 (48.1)	329 (31.2)	757 (28.9)
Medium	7023 (69.1)	161 (15.0)	471 (35.8)	3263 (28.1)	650 (42.0)	15788 (29.0)	935 (41.4)	540 (51.2)	1562 (59.7)
Low	1703 (16.8)	630 (58.6)	59 (4.5)	534 (4.6)	355 (23.0)	935 (1.7)	236 (10.5)	186 (17.6)	299 (11.4)
Missing data[2]	429 (4.1)	93 (8.0)	5 (0.4)	2 (0.0)	20 (1.3)	3096 (5.4)	0 (0.0)	105 (9.7)	7 (0.3)
Country of birth									
Born in country of cohort	8946 (95.7)	728 (62.4)	1271 (97.1)	10512 (90.4)	1453 (92.0)	NA	2074 (92.6)	970 (93.9)	2451 (94)
Missing data[2]	1244 (11.4)	1 (0.1)	12 (0.9)	0 (0.0)	0 (0.0)	NA	19 (0.8)	53 (4.9)	18 (0.7)
Parity (first child)									
Yes	4619 (45.4)	449 (39.4)	615 (46.7)	5278 (46)	925 (58)	28358 (49.6)	1314 (58.6)	471 (44.2)	1384 (52.8)
Missing data	411 (3.9)	29 (2.5)	3 (0.2)	149 (1.3)	0 (0.0)	463 (0.8)	19 (0.8)	21 (1.9)	3 (0.1)
Child factors									
Sex									
Females	5120 (48.3)	607 (52)	627 (47.4)	5685 (49)	771 (49.0)	27178 (48.8)	1122 (49.7)	530 (48.9)	1258 (47.9)
Missing data[2]	0 (0.0)	0 (0.0)	0 (0.0)	22 (0.2)	0 (0.0)	1949 (3.4)	0 (0.0)	0 (0.0)	0 (0.0)
BMI status at preschool age									
Mean age in months	42.5 (1.6)	36.6 (1.1)	37.6 (1.0)	41.3 (3.8)	52.7 (1.7)	36.0 (0.0)	52.6 (2.4)	50.0 (1.8)	36.8 (1.1)
Normal or underweight	995 (92.1)	907 (92.5)	1245 (97.7)	6788 (97.2)	1424 (91.1)	37819 (93.2)	1688 (94.7)	750 (87.9)	2328 (92.9)
Children with overweight or obese	85 (7.9)	73 (7.5)	29 (2.3)	196 (2.8)	139 (8.9)	2758 (6.8)	94 (5.27)	103 (12.1)	178 (7.1)
Missing data[2]	9515 (89.8)[4]	188 (16.1)	47 (3.5)	4639 (39.9)	21 (1.3)	17020 (29.6)	476 (21.1)	233 (16.0)	119 (4.5)

For each variable, distribution values are provided for children with lifestyle pattern scores and expressed as means (SD) or numbers (%); NA : Not available

[1]The higher the quintiles, the higher the income

[2] Missing data for children with lifestyle pattern scores

[3]Classification according to International Standard Classification of Education 97/2011 (ISCED-97/2011) - High: Short cycle tertiary, Bachelor, Masters, Doctoral or equivalent (ISCED-2011: 5-8, ISCED-97: 5-6); Medium: Upper secondary, Post-secondary non-tertiary (ISCED-2011: 3-4, ISCED-97: 3-4); Low: No education, early childhood, pre-primary, primary, lower secondary or second stage of basic education

[4] Of note, only a 10% sample of the ALSPAC cohort, known as the Children in Focus (CiF) group, attended clinics at the University of Bristol at various time intervals between 4 to 61 months of age. The CiF sample was chosen at random from the last 6 months of ALSPAC births occurring in 1992 (1432 families attended at least one clinic).

Table 2. PCA loadings for lifestyle patterns (LP) derived at preschool age[1].

	ALSPAC, 1991 (n=10 595) 3 years		BiB, 2007 (n=1 168) 3 years		EDEN, 2003 (n=1 321) 3 years		ELFE, 2011 (n=11 623) 3.5 years		INMA, 2003 (n=1 584) 4 years		MoBa, 1999 (n=57 597) 3 years		Piccolipiù, 2011 (n=2 258) 4 years		RHEA, 2003(n=1 086) 4 years		SWS, 1998 (n=2 625) 3 years	
	LP1	LP2	LP1	LP2	LP1	LP2	LP1	LP2	LP1	LP2	LP1	LP2	LP1	LP2	LP1	LP2	LP1	LP2
Vegetables	-0.19	**0.69**	**-0.58**	**0.53**	**-0.32**	**0.57**	**-0.30**	**0.69**	0.05	**0.75**	**-0.52**	**0.32**	0.05	**0.72**	**-0.31**	**0.67**	**-0.54**	**0.55**
Fruit	**-0.30**	**0.55**	**-0.30**	**0.63**	-0.20	**0.66**	-0.17	**0.71**	0.14	**0.65**	**-0.44**	**0.44**	0.05	**0.61**	**-0.35**	**0.65**	**-0.47**	**0.49**
Fish	-0.06	**0.56**	**-0.44**	**0.48**	0.23	**0.57**	0.01	**0.51**	0.11	**0.68**	**-0.36**	**0.55**	0.05	**0.32**	**-0.45**	**0.42**	**-0.45**	**0.41**
Discretionary savory foods	**0.61**	0.05	0.26	**0.67**	**0.71**	0.12	**0.61**	0.17	**0.47**	-0.08	**0.48**	**0.40**	-0.24	-0.04	NA	NA	**0.40**	**0.45**
Discretionary sweet foods	**0.80**	0.27	**0.46**	**0.58**	**0.64**	0.01	**0.53**	0.14	**0.42**	-0.25	**0.50**	**0.40**	0.01	-0.16	**0.41**	**0.47**	**0.57**	**0.33**
Processed meat	**0.38**	-0.07	-0.27	0.19	**0.51**	**0.45**	**0.48**	0.20	**0.55**	0.24	**-0.17**	**0.61**	-0.08	**-0.40**	**0.56**	**0.38**	**0.41**	**0.47**
Sweet beverages	**0.74**	0.25	**0.30**	**0.61**	**0.61**	-0.05	**0.59**	0.21	**0.60**	-0.03	**0.47**	**0.34**	-0.06	**-0.42**	**0.41**	**0.39**	**0.61**	0.20
TV screen time	**0.51**	-0.21	**0.62**	0.13	**0.52**	-0.20	**0.53**	-0.12	**0.55**	-0.20	**0.46**	0.16	**0.68**	-0.10	**0.54**	0.13	**0.51**	-0.02
Other screen time	NA	NA	**0.44**	0.10	NA	NA	**0.49**	-0.04	NA	NA	NA	NA	**0.67**	-0.11	NA	NA	NA	NA
Outdoor play time	0.12	**0.34**	0.09	0.15	0.17	0.20	0.21	0.06	NA	NA	-0.25	0.13	**-0.38**	-0.11	-0.09	0.29	0.10	**0.36**
Sleep duration	0.00	0.08	-0.10	0.06	-0.28	0.12	-0.23	0.08	-0.20	**0.33**	**-0.43**	-0.20	**-0.39**	0.10	-0.24	0.14	-0.10	0.01
Variance explained	20.6	14.1	15.1	19.4	20.6	14.1	17.8	13.4	15.7	18.9	18.1	14.7	11.8	12.7	16.5	18.5	19.9	14.3

[1] For each cohort, the indicated year in the table refers to the one when the majority of EBRBs was ascertained
LP1: 'unhealthy' lifestyle pattern
LP2: 'healthy' lifestyle pattern (ALSPAC, ELFE, INMA, Piccolipiù) or 'mixed' lifestyle pattern (BiB, EDEN, MoBa, RHEA, SWS)

NA: Not available

In bold: factor loadings >0.30 or <-0.30

Table 3a. Associations between socio-demographic factors and the unhealthy lifestyle pattern in different European countries: β (95% CI) from complete-cases linear regressions.

	ALSPAC, 1991 (n=8 143)[1]		BiB, 2007 (n=1 075)[1]		EDEN, 2003 (n=1 269)[1]	
	Univariable	Multivariable	Univariable	Multivariable	Univariable	Multivariable
Household income (EHII-score, quintiles[2])						
Fifth	ref	ref	ref	ref	ref	ref
Fourth	0.41 (0.31;0.50)	0.26 (0.16;0.36)	-0.25 (-0.50;-0.01)	-0.26 (-0.52;0.00)	0.04 (-0.18;0.27)	-0.04 (-0.27;0.18)
Third	0.53 (0.43;0.63)	0.22 (0.12;0.33)	-0.15 (-0.39;0.09)	-0.13 (-0.39;0.12)	0.19 (-0.03;0.42)	-0.09 (-0.33;0.16)
Second	0.72 (0.62;0.82)	0.27 (0.16;0.38)	-0.66 (-0.90;-0.42)	-0.80 (-1.17;-0.44)	0.76 (0.53;0.99)	0.29 (0.00;0.57)
First	1.03 (0.93;1.14)	0.48 (0.35;0.60)	-0.43 (-0.67;-0.20)	-0.41 (-0.70;-0.12)	1.08 (0.82;1.34)	0.43 (0.10;0.77)
Maternal education level at inclusion						
High	ref	ref	ref	ref	ref	ref
Medium	0.94 (0.84;1.01)	0.79 (0.70;0.89)	-0.24 (-0.49;0.00)	-0.48 (-0.75;-0.20)	0.77 (0.62;0.93)	0.57 (0.35;0.78)
Low	1.54 (1.44;1.65)	1.23 (1.09;1.37)	0.27 (0.09;0.45)	-0.18 (-0.45;0.10)	1.39 (1.03;1.75)	0.97 (0.55;1.40)
Maternal age at delivery (years)	-0.02 (-0.03;-0.01)	-0.02 (-0.02;-0.01)	-0.01 (-0.02;0.01)	0.01 (0.00;0.03)	-0.03 (-0.05;-0.01)	-0.01 (-0.03;0.01)
Parity						
Primiparity	ref	ref	ref	ref	ref	ref
Multiparity	0.32 (0.26;0.38)	0.19 (0.12;0.26)	0.06 (-0.10;0.21)	-0.10 (-0.28;0.08)	0.09 (-0.07;0.24)	0.05 (-0.11;0.22)
Child's sex						
Girls	ref	ref	ref	ref	ref	ref
Boys	0.09 (0.03;0.15)	0.08 (0.02;0.15)	-0.14 (-0.29;0.01)	-0.15 (-0.31;0.00)	0.17 (0.01;0.32)	0.17 (0.02;0.32)

CI: Confidence intervals, ref: reference category

[1]n for multivariable analyses (adjusted for all variables displayed in the table)

[2]The higher the quintiles, the higher the incomes

Table 3b. Associations between socio-demographic factors and the unhealthy lifestyle pattern in different European countries: β (95% CI) from complete-cases linear regressions.

	ELFE, 2011 (n=10 228)[1]		INMA, 2003 (n=1 445)[1]		MoBa, 1999 (n=49 287)[1]	
	Univariable	Multivariable	Univariable	Multivariable	Univariable	Multivariable
Household income (EHII-score, quintiles[2])						
Fifth	ref	ref	ref	ref	ref	ref
Fourth	0.19 (0.12;0.26)	0.15 (0.08;0.22)	0.22 (0.00;0.44)	0.07 (-0.15;0.29)	-0.06 (-0.10;-0.03)	-0.04 (-0.08;-0.01)
Third	0.42 (0.34;0.49)	0.31 (0.23;0.39)	0.53 (0.31;0.75)	0.22 (-0.04;0.48)	0.19 (0.16;0.23)	0.15 (0.12;0.19)
Second	0.77 (0.70;0.85)	0.53 (0.44;0.62)	0.81 (0.59;1.03)	0.40 (0.12;0.68)	0.44 (0.41;0.48)	0.22 (0.18;0.26)
First	1.57 (1.48;1.65)	1.16 (1.05;1.27)	0.88 (0.66;1.10)	0.40 (0.10;0.70)	0.42 (0.38;0.46)	0.19 (0.14;0.24)
Maternal education level at inclusion						
High	ref	ref	ref	ref	ref	ref
Medium	0.81 (0.75;0.86)	0.29 (0.22;0.36)	0.55 (0.40;0.70)	0.32 (0.12;0.52)	0.47 (0.44;0.49)	0.31 (0.27;0.34)
Low	1.49 (1.37;1.60)	0.78 (0.64;0.92)	0.82 (0.62;1.02)	0.48 (0.22;0.74)	0.74 (0.66;0.83)	0.56 (0.46;0.66)
Maternal age at delivery (years)	-0.04 (-0.04;-0.03)	-0.01 (-0.02;-0.01)	-0.05 (-0.07;-0.03)	-0.04 (-0.06;-0.02)	-0.02 (-0.02;-0.01)	-0.01 (-0.02;-0.01)
Parity						
Primiparity	ref	ref	ref	ref	ref	ref
Multiparity	0.22 (0.16;0.27)	0.14 (0.09;0.20)	-0.02 (-0.16;0.12)	0.09 (-0.07;0.25)	0.23 (0.21;0.25)	0.28 (0.25;0.30)
Child's sex						
Girls	ref	ref	ref	ref	ref	ref
Boys	0.13 (0.08;0.18)	0.14 (0.09;0.18)	0.17 (0.03;0.31)	0.13 (-0.01;0.27)	0.14 (0.12;0.16)	0.14 (0.12;0.17)

CI: Confidence intervals, ref: reference category

[1]n for multivariable analyses (adjusted for all variables displayed in the table)

[2]The higher the quintiles, the higher the incomes

Table 3c. Associations between socio-demographic factors and the unhealthy lifestyle pattern in different European countries: β (95% CI) from complete-cases linear regressions.

	Piccolipiù, 2011 (n=2 126)[1]		RHEA, 2003 (n=902)[1]		SWS, 1998 (n=1 853)[1]	
	Univariable	Multivariable	Univariable	Multivariable	Univariable	Multivariable
Household income (EHII-score, quintiles[2])						
Fifth	ref	ref	ref	ref	ref	ref
Fourth	0.21 (0.07;0.36)	0.17 (0.03;0.32)	0.34 (0.07;0.61)	0.19 (-0.10;0.49)	0.48 (0.29;0.66)	0.13 (-0.05;0.32)
Third	0.26 (0.11;0.41)	0.17 (0.02;0.33)	0.16 (-0.12;0.44)	-0.05 (-0.38;0.28)	0.74 (0.55;0.93)	0.22 (0.01;0.43)
Second	0.17 (0.02;0.32)	0.04 (-0.13;0.21)	0.58 (0.29;0.86)	0.33 (-0.02;0.67)	1.14 (0.95;1.33)	0.44 (0.23;0.66)
First	0.41 (0.25;0.57)	0.28 (0.08;0.47)	0.85 (0.56;1.14)	0.56 (0.17;0.96)	1.52 (1.33;1.71)	0.63 (0.40;0.85)
Maternal education level at inclusion						
High	ref	ref	ref	ref	ref	ref
Medium	0.24 (0.15;0.34)	0.20 (0.08;0.31)	0.36 (0.17;0.56)	0.23 (-0.02;0.49)	0.92 (0.81;1.04)	0.55 (0.39;0.72)
Low	0.35 (0.19;0.51)	0.29 (0.10;0.48)	0.59 (0.34;0.85)	0.24 (-0.11;0.60)	1.64 (1.47;1.82)	1.10 (0.85;1.34)
Maternal age at delivery (years)	0.01 (0.00;0.02)	0.02 (0.00;0.03)	-0.04 (-0.05;-0.02)	-0.02 (-0.04;0.00)	-0.07 (-0.08;-0.05)	-0.05 (-0.07;-0.04)
Parity						
Primiparity	ref	ref	ref	ref	ref	ref
Multiparity	0.17 (0.07;0.26)	0.09 (-0.01;0.19)	-0.09 (-0.26;0.08)	-0.10 (-0.29;0.10)	0.74 (0.64;0.85)	0.53 (0.41;0.65)
Child's sex						
Girls	ref	ref	ref	ref	ref	ref
Boys	-0.01 (-0.11;0.08)	-0.02 (-0.12;0.07)	0.15 (-0.02;0.31)	0.12 (-0.06;0.31)	0.14 (0.04;0.25)	0.08 (-0.05;0.18)

CI: Confidence intervals, ref: reference category

[1]n for multivariable analyses (adjusted for all variables displayed in the table)

[2]The higher the quintiles, the higher the income

1

Table 4. Cross-sectional associations between the unhealthy lifestyle pattern and BMI z-scores or overweight status in different European countries: β or OR (95% CI) from complete-cases linear or logistic regressions.

	BMI status at preschool age[1]			
	BMI z-scores β (95% CI)		Children with overweight OR (95% CI)	
	Univariable	Multivariable[2]	Univariable	Multivariable[2]
Unhealthy lifestyle pattern at preschool age[3]				
ALSPAC (n=952), 3 years	0.02 (-0.02;0.06)	0.01 (-0.03;0.06)	1.02 (0.88;1.19)	0.98 (0.82;1.16)
BIB (n=878), 3 years	-0.05 (-0.10;0.00)	-0.05 (-0.10;0.00)	0.94 (0.78;1.13)	0.95 (0.77;1.16)
EDEN (n=1 246), 3 years	0.00 (-0.03;0.04)	0.00 (-0.03;0.04)	1.09 (0.88;1.34)	1.04 (0.83;1.31)
ELFE (n=6 277), 3.5 years	0.03 (0.01;0.04)	0.00 (-0.02;0.02)	1.15 (1.06;1.26)	1.00 (0.89;1.12)
INMA (n=1 428), 4 years	0.05 (0.01;0.10)	0.06 (0.02; 0.10)	1.26 (1.13;1.42)	1.28 (1.13;1.44)
MOBA (n=36 108), 3 years	-0.03 (-0.03;-0.02)	-0.03 (-0.04;-0.02)	0.99 (0.96;1.02)	0.97 (0.94;1.00)
Piccolipiù (n=1 782), 4 years	0.06 (0.02;0.10)	0.06 (0.02;0.10)	1.19 (1.00.1.42)	1.18 (0.99.1.42)
RHEA (n=710), 4 years	0.04 (-0.02;0.10)	0.02 (-0.04;0.09)	1.16 (1.01;1.34)	1.12 (0.96;1.32)
SWS (n=1 783), 3 years	0.02 (-0.01;0.05)	0.00 (-0.04;0.03)	1.22 (1.10;1.36)	1.11 (0.96;1.28)

[1]On average BMI ascertained at – mean in years (SD), for ALSPAC: 3.5 (0.1); BiB: 3.1 (0.1); EDEN: 3.1 (0.1); ELFE: 3.4 (0.3); INMA: 4.3 (0.1); MoBa: 3.0 (0.0); Piccolipiù: 4.4 (0.2); RHEA: 4.2 (0.1); SWS: 3.1 (0.09)

[2] Analyses adjusted for: household income, maternal age at delivery, maternal educational level, parity, and child sex

[3] For each cohort, the indicated year refers to the one when the majority of EBRBs was ascertained

Supplemental material

Supplementary material 1. Background information on the participating cohorts.

The study includes participant data from nine population-based birth and pregnancy cohorts in six European countries (**Supplementary Table 1**):

- the Avon Longitudinal Study of Parents and Children (ALSPAC), the Southampton Women's Survey (SWS) and the Born in Bradford (BiB) study in the UK;
- the Étude des Déterminants pré et postnatals du développement et de la santé de l'Enfant (EDEN) and the Etude Longitudinale Française depuis l'Enfance (ELFE) in France;
- the INfancia y Medio Ambiente (INMA) cohort in Spain;
- the Norwegian Mother, Father and Child Cohort Study (MoBa);
- the Piccolipiu study in Italy;
- and the RHEA Mother Child Cohort in Crete, Greece.

The various cohorts were started between 1990 (ALSPAC) and 2011 (ELFE, Piccolipiù). Recruitment took place before pregnancy in the SWS cohort. Three cohorts (INMA, ALSPAC, RHEA) recruited pregnant women during the first trimester of pregnancy; two (EDEN, MoBa) through the first and second trimesters; while in the BiB cohort, women were recruited between weeks 26 and 28 of gestation (third semester). In the ELFE cohort, recruitment took place at birth, whereas in the Piccopiliù cohort, it ranged from early pregnancy to birth (depending on the city). Inclusion and exclusion criteria varied between cohorts, as described in **Supplementary Table 1**. All cohorts included at least one follow-up point during pregnancy (except for ELFE), one at birth, and several after delivery.

Supplementary Table 1. Characteristics of the cohorts contributing to the present study

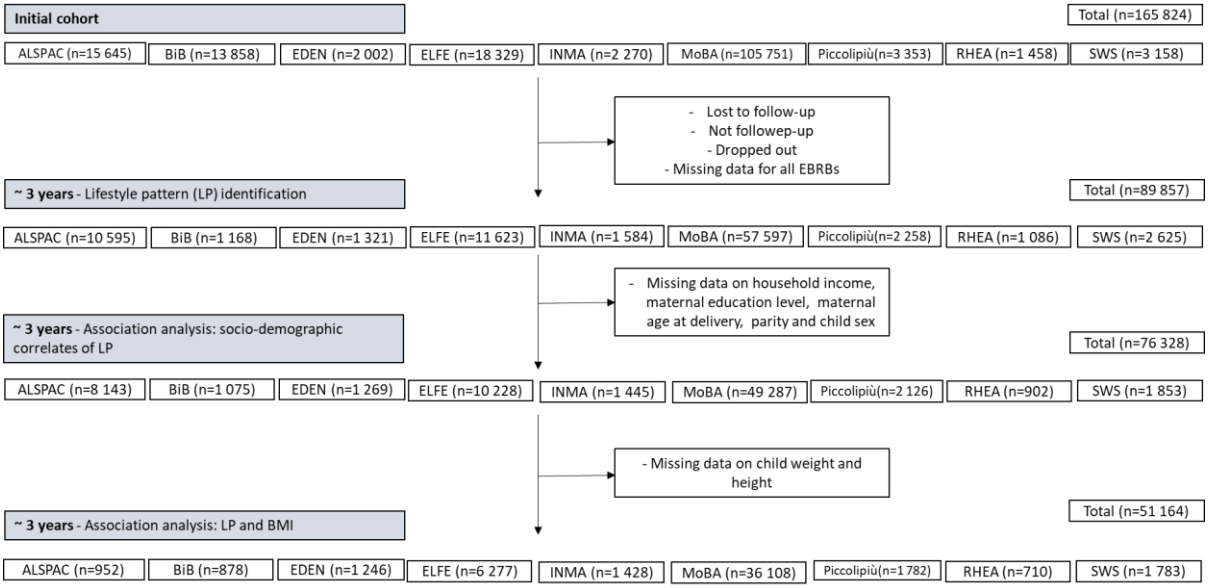
Cohort	Recruitment in original cohort	Exclusions made during recruitment	Years of start of the cohort	Region covered
ALSPAC, UK	Pregnant women residents in the old administrative county of Avon were eligible to participate in ALSPAC if their estimated delivery date fell between 1 April 1991 and 31 December 1992 inclusive. Women were recruited as early in pregnancy as possible. 20,248 pregnancies have been identified as being eligible and the initial number of pregnancies enrolled was 14,541. When the oldest children were approximately 7 years of age, an attempt was made to bolster the initial sample with eligible cases who had failed	Pregnant women originally resident in Avon but moving away of the recruitment area prior to delivery were excluded unless they had completed the questionnaire scheduled for the third trimester of pregnancy.	1991-1992	Avon

	to join the study originally, resulting in a sample of 15,645 children.			
BiB, UK	All pregnant women who attended the oral glucose tolerance test clinic at Bradford Royal Infirmary in weeks 26–28 of pregnancy.	Women who planned to move away from Bradford before birth.	2007–2010	Bradford
EDEN, France	Pregnant women who attended maternity units at the University hospitals of Nancy and Poitiers recruited before 24 weeks of amenorrhoea.	Twin pregnancies, women with known diabetes before pregnancy, insufficient French language skills and intention to move away from the recruitment area.	2003–2006	Nancy and Poitiers
ELFE, France	Women born in randomly selected maternity units during fours periods over the year 2011.	Exclusion criteria were births at <33 weeks of gestation, mother <18 years old, plan to leave mainland France within 3 years.	2011	Mainland France
INMA, Spain	Pregnant women who attended a prenatal care centre in the study region during weeks 6–10 of pregnancy.	Women who resided or intended to deliver outside the study area, who were aged under 16 years, who had twin or multiple pregnancies, who had assisted reproduction or who had communication problems.	2003–2008	Gipuzkoa, Sabadell, Valencia
MoBa, Norway	Recruitment at the first ultrasound scan, i.e. during the 17–18 weeks of gestation. All women who gave singleton births in the participating maternity units.	None	1999–2008	Oslo
Piccolipiu, Italy	All singleton pregnant women giving birth in one of the selected maternity units. They were invited to participate in the study at different times during the pregnancy.	Women < 18 years old, not resident in the catchment area of the maternity centers, not enough knowledge of the Italian language to adequately understand the informed consent and to complete the questionnaires; no telephone number they can be reached at.	2011-2014	Five Italian cities (Florence, Rome, Trieste, Turin, and Viareggio)

RHEA, Greece	Pregnant women who attended ultrasound examination before 15 weeks of pregnancy with residence in and near Heraklion in Crete.	Women < 16 years, who had communication problems.	2007–2008	Heraklion
SWS, UK	All general practitioners in Southampton were asked to help recruit non-pregnant women aged 20-34 years to the study. Women who become pregnant were recruited into the pregnancy phase of the SWS. They visited the SWS Ultrasound Unit at the Princess Anne Hospital in Southampton at 11, 19- and 34-weeks gestation.	None	1998-2007	Southampton

ALSPAC, Avon Longitudinal Study of Parents and Children; BiB, Born in Bradford; EDEN, Étude des Déterminants pré et postnatals du développement et de la santé de l'Enfant; ELFE, Etude Longitudinale Française depuis l'Enfance; INMA, INfancia y Medio Ambiente; MoBa, Norwegian Mother, Father and Child Cohort Study; SWS, Southampton Women's Survey.

Supplementary material 2. Flow chart illustrating participants included in the study.



ALSPAC, Avon Longitudinal Study of Parents and Children; BiB, Born in Bradford; EDEN, Étude des Déterminants pré et postnatals du développement et de la santé de l'Enfant; ELFE, Etude Longitudinale Française depuis l'Enfance; INMA, INfancia y Medio Ambiente; MoBa, Norwegian Mother, Father and Child Cohort Study; SWS, Southampton Women's Survey.

Supplementary material 3. Description of energy balance-related behaviors (EBRBs) assessment and harmonization in each cohort.

Here we describe how EBRBs were assessed and harmonized in each cohort. This information is synthesized in **Supplementary Tables 3a-3d**, which is followed by the exact cohort-phrasing of each question.

Supplementary Table 3a. Questions on food consumption asked in the survey questionnaires (summary) and harmonization.

Cohorts	Diet (FFQ)		
	Initial numbers of items	Selected items	Age[1]
ALSPAC: 1991-92	106	27	3
BiB: 2007-10	140	61	3
EDEN: 2003-06	28	14	3
ELFE: 2011	20	11	2
INMA: 2003-08	105	58	4
MoBa: 1999-08	37	15	3
Piccolipiù: 2011-14	47	11	4
RHEA: 2007-08	118	18	4
SWS: 1998-2002	80	23	3

[1] in years; FFQ: food frequency questionnaire

ALSPAC, Avon Longitudinal Study of Parents and Children; BiB, Born in Bradford; EDEN, Étude des Déterminants pré et postnatals du développement et de la santé de l'Enfant; ELFE, Etude Longitudinale Française depuis l'Enfance; INMA, INfancia y Medio Ambiente; MoBa, Norwegian Mother, Father and Child Cohort Study; SWS, Southampton Women's Survey.

Harmonization:

The FFQs were diverse and ranged from 20 (for ELFE) to 140 (for BiB) items with different types of possible response categories. First, when necessary, the frequency of consumption of each selected FFQ item was calculated by converting it into daily equivalents (times or servings/day).

- *ALSPAC:* never or rarely (0); once in two weeks (0.5/7); 1-3 times a week (2/7); 4-7 times a week (5.5/7); or more than once a day (10/7)
- *BIB:* Rarely or never (0); 1 or 2 per month (0.05); 1 per week (0.14); 2-3 per week (0.36); 4-6 per week (0.71); 1 per day (1); 2-3 per day (2.5); 4-6 per day (5); 7+ per day (8).
- *EDEN:* Never (0); Less than once a month (0.5*12/365.25); 1 to 3 times a month (2*12/365.25); 1 to 3 times a week (2*52/365.25); 4 to 6 times a week (5*52/365.25); Once a day (1); Several times a day (2)
- *ELFE:* Never (0); Less often (1*12/365.25); Several times a month (2*12/365.25); Several times a week (3*52/365.25); Once a day (1); Several times a day (2);
- *INMA:* continuous (servings/day)
- *MoBa:* Less than once a week (1/7), 1-3 times a week (2/7), 4-6 times a week (5/7), once in 24 hours (1), twice in 24 hours (2), 3 times in 24 hours (3), 4 or more times in 24 hours (5)
- *Piccolipiù:* Never (0); times per months (*times/30*); times per week (*times/7*) ; times per day
- *RHEA:* continuous (servings/day)
- *SWS:* continuous (times/week)/7

The larger food groups, i.e., vegetables (without potatoes), fruit, fish, discretionary savory foods, discretionary sweet food, processed meat, and sweet beverages were then created based on similarities in food type and context of consumption and the appropriate converted frequencies summed accordingly.

Supplementary Table 3b. Questions on screen time asked in the survey questionnaires (summary) and harmonization.

TV				
Cohorts	Initial variable type	Details	Days distinction[1]	Age[2]
ALSPAC: 1991-92	categorical		yes	3
BiB: 2007-10	categorical		yes	3
EDEN: 2003-06	continuous	TV/DVD/computer	yes	3
ELFE: 2011	continuous		yes	3.5
INMA: 2003-08	continuous		no	4
MoBa: 1999-08	categorical	TV/video	no	3
Piccolipiù: 2011-14	categorical		yes	4
RHEA: 2007-08	continuous	TV/video	yes	4
SWS: 1998-2002	categorical		no	3

Other screens				
Cohorts	Initial variable type	Details	Days distinction[1]	Age[2]
ALSPAC: 1991-92	x	x	x	x
BiB: 2007-10	categorical	computer	no	3
EDEN: 2003-06	x	x	x	x
ELFE: 2011	continuous	computer, video games, tablet, phones	yes	3.5
INMA: 2003-08	x	x	x	x
MoBa: 1999-08	x	x	x	x
Piccolipiù: 2011-14	categorical	tablet/smartphone	yes	4
RHEA: 2007-08	x	x	x	x
SWS: 1998-2002	x	x	x	x

[1] question distinguishing week and week-end days; [2] in years; x: not available

ALSPAC, Avon Longitudinal Study of Parents and Children; BiB, Born in Bradford; EDEN, Étude des Déterminants pré et postnatals du développement et de la santé de l'Enfant; ELFE, Etude Longitudinale Française depuis l'Enfance; INMA, INfancia y Medio Ambiente; MoBa, Norwegian Mother, Father and Child Cohort Study; SWS, Southampton Women's Survey.

Harmonization:

• TV: In ALSPAC, BiB, MoBa, Piccolipiù and SWS responses included between four and seven categories. Numeric values (expressed in hours/day) were assigned to these categorical answer categories responses to convert the variables to a numerical scale (expressed in hours/day), as follows: in ALSPAC (0; 0.5; 1.5; 2.5), in BiB (0; 0.5; 1.5; 2.5; 3.5; 4.5), in MoBa (0; 0.5; 1.5; 3; 4), in Piccolipiù and SWS (0; 0.5; 1.5; 2.5; 3.5; 4.5; 5.5).

For variables split into weekdays and weekend days (i.e., ALSPAC, BiB, EDEN, ELFE, Piccolipiù, RHEA), usual TV time (hours/day) was computed as [(week days × 5) + (weekend days × 2)]/7.

•Other screens: In BiB and Piccolipiù, the response categories respectively included the following: "up to 15 min a day; 16-30 min a day; 31-60 min a day" and "never; <1hour/day; 1-1.999 hours/day; 2-2.999 hours/day; 3-4.999 hours/day; 4-5.999 hours/day; ≥5 hours/day". These categories were thus converted to a numerical scale (expressed in hours/day), as follows: in BiB (7.5/60; 23/60;

45.5/60) and in Piccolipiù (0; 0.5; 1.5; 2.5; 3.5; 4.5; 5). In BiB, if children spent more than one hour playing with a computer per day, parents provided the exact time doing so.

In ELFE and Piccolipiù, the average hours per day on these other screens was computed as [(week days × 5) + (weekend days × 2)]/7.

Supplementary Table 3c. Questions on outdoor play time asked in the survey questionnaires (summary) and harmonization.

	Outdoor play time			
Cohorts	Initial variable type	Details	Days distinction[1]	Age[2]
ALSPAC: 1991-92	categorical	time spent outside	yes	3
BiB: 2007-10	categorical	garden & park	no	3
EDEN: 2003-06	continuous	playing outside	yes	3
ELFE: 2011	continuous	when the weather is fair	yes	3.5
INMA: 2003-08	x	x	x	x
MoBa: 1999-08	categorical	time spent outside	no	3
Piccolipiù: 2011-14	continuous	playing outside	week end	4
RHEA: 2007-08	continuous	time spent outside	yes	4
SWS: 1998-2002	continuous	time spent outside	no	3

[1] question distinguishing week and week-end days; [2] in years; x: not available

ALSPAC, Avon Longitudinal Study of Parents and Children; BiB, Born in Bradford; EDEN, Étude des Déterminants pré et postnatals du développement et de la santé de l'Enfant; ELFE, Etude Longitudinale Française depuis l'Enfance; INMA, INfancia y Medio Ambiente; MoBa, Norwegian Mother, Father and Child Cohort Study; SWS, Southampton Women's Survey.

Harmonization:

Three cohorts provided various response categories when assessing time spent (playing) outdoors: ALSPAC (not at all; less than 1 hour; 1-2 hours a day; more than 2 hours a day), BiB (Up to 15 mins/day; 16-30 mins/day; 31-60 mins/day) and MoBa (seldom; frequently, but less than 1 hour a day on average; 1-3 hours a day on average; more than 3 hours a day). These categories were converted to a numerical scale (expressed in hours/day), as follows: in ALSPAC (0; 0.5; 1.5; 2.5), in BiB (0; 7.5:60; 23:60; 45.5:60), in MoBa (0; 0.5; 2; 3.5). In BiB, if children spent more than one hour playing outside per day, parents provided the exact time doing so. After continuous transformations, time playing in the 'garden' and 'parks' were summed.

In EDEN, ELFE, Piccolipiù, RHEA and SWS outdoor (play) time was ascertained through open-ended questions.

For variables split into week and week-end days (ALSPAC, EDEN, ELFE, RHEA), usual time spent (playing) outdoors (hours/day) was computed as [(week days × 5) + (weekend days × 2)]/7. In Piccolipiù, usual time playing outside was computed as (saturday time + sunday time) /2.

Finally, in each cohort, time spent (playing) outdoors were standardized by season.

Supplementary Table 3d. Questions on sleep time asked in the survey questionnaires (summary) and harmonization.

Sleep (night) duration				
Cohorts	Initial variable type	Details	Days distinction[1]	Age[2]
ALSPAC: 1991-92	continuous	bed & wake up time	no	3.5
BiB: 2007-10	continuous	amount	no	3
EDEN: 2003-06	continuous	bed & wake up time	no	3
ELFE: 2011	continuous	bed & wake up time	yes	3.5
INMA: 2003-08	continuous	amount	no	4
MoBa: 1999-08	categorical	amount	week-days	5
Piccolipiù: 2011-14	continuous	amount	no	4
RHEA: 2007-08	continuous	amount	no	4
SWS: 1998-2002	continuous	bed & wake up time	no	3

Sleep (day – nap) duration				
Cohorts	Initial variable type	Details	Days distinction[1]	Age[2]
ALSPAC: 1991-92	categorical	amount	no	3.5
BiB: 2007-10	continuous	amount	no	3
EDEN: 2003-06	continuous	amount	no	3
ELFE: 2011	continuous	amount	yes	3.5
INMA: 2003-08	x	x	x	x
MoBa: 1999-08	x	x	x	x
Piccolipiù: 2011-14	continuous	amount	no	4
RHEA: 2007-08	continuous	amount	no	4
SWS: 1998-2002	continuous	amount	no	3

[1] question distinguishing week and week-end days; [2] in years; x: not available

ALSPAC, Avon Longitudinal Study of Parents and Children; BiB, Born in Bradford; EDEN, Étude des Déterminants pré et postnatals du développement et de la santé de l'Enfant; ELFE, Etude Longitudinale Française depuis l'Enfance; INMA, INfancia y Medio Ambiente; MoBa, Norwegian Mother, Father and Child Cohort Study; SWS, Southampton Women's Survey.

Harmonization:

Night sleep time was either computed from bedtime day and awake time, or directly obtained from an open response. In MoBa, the response categories for the night sleep time were transformed as follows: 8h/day; 9h/day; 10h/day; 11h/day; 12h/day. In ALSPAC, the nap duration variable was primarily categorical (none; <1 h/day; 1-2 h/day; >2 h/day), and was therefore transformed into a quantitative value (0 h/day; 0.5 h/day; 1.5 h/day; 2.5 h/day) before being summed with night time.

ALSPAC (started 1991)

Diet:

- **FFQ (27 items used) -** *Available at 3 years old*.
    - Vegetables: peas, sweetcorn or broad beans; cabbage, Brussel sprouts, kale or other green leafy vegetables; other green vegetables; carrots; other root vegetables; salad
    - Fruit: fresh fruit, tinned fruit juice, pure fruit juice
    - Fish: fish fingers; white fish; other fish; shellfish
    - Discretionary savory food: crisps
    - Discretionary sweet food: pudding; cakes or buns; biscuits; chocolate biscuits; chocolate bars; chocolate; sweets; cola drinks; other fizzy drinks
    - Processed meat: burgers or sausages
    - Sweet beverages: cola drinks; other fizzy drinks

Sedentary behavior:

- **Time spent watching TV -** *3 years*.
    - "How much time on average does your child spend: ***On most weekdays***: watching T.V.?" (Not at all; less than 1 hour; 1-2 hours; more than 2 hours);
    - "How much time on average does your child spend: ***On most weekend days***: watching T.V.?" (Not at all; less than 1 hour; 1-2 hours; more than 2 hours).

Physical activity:

- **Outdoors activities -** *3 years*.
    - "How much time on average does your child spend, ***on most weekdays***: out of doors" (not at all; less than 1 hour; 1-2 hours a day; more than 2 hours a day);
    - "How much time on average does your child spend, ***on most weekend days***: out of doors" (not at all; less than 1 hour; 1-2 hours a day; more than 2 hours a day).

Sleep:

- **Amount of sleep per day -** *3.5 years*. "How many hours of sleep does your child usually have during the day time?" (none; less than 1 hour; 1-2 hours; more than 2 hours; don't know);
- **Amount of sleep per night -** *3.5 years*.
    - "Normally what time in the evening does your child ***go to sleep***?" (Time).
    - **"**What time does he normally ***wake up*** in the morning?" (Time).

BiB (started 2007)

Diet:

- **FFQ (61 items used) -** *Available at 3 years old*.
    - Vegetables: Mixed vegetable dishes, Peas/green beans, Sweetcorn, Broccoli, Cabbage, Spinach, Other green veg, Cauliflower/swede/turnip, Raw carrot, Cooked carrot, Onions, Tomatoes, Peppers, Other salad veg, Coleslaw
    - Fruit: Fresh fruit salad, Tinned fruit, Apples, Oranges, Bananas, Grapes/melon/pear, Kiwi, Other fresh fruit, Dried fruit, Pure apple juice, Other pure fruit juice
    - Fish: Fish fingers, Fish cakes/pies, Grilled/poached white fish, White fish fried/cooked in batter scampi, Fried oily fish, Smoked oily fish, Tinned tuna, Tinned salmon/sardines/mackerel/pilchards, Prawns
    - Discretionary savory food: Regular crisps, Reduced-fat crisps, Other savory snacks, Peanuts/other nuts, Savory biscuit/crackers/breadsticks
    - Discretionary sweet food: Sugar, Jam/honey/snacks, Chocolate spread, Cereal bars/flapjacks, Jelly, Boiled/chewy/chocolate sweets, Chocolate bars
    - Processed meat: Frankfurters, Fried/grilled sausages, Bacon/gammon, Cold ham/turkey, Salami/continental sausage, Stewed/fried/grilled/roast beef/pork/lamb, Chicken nuggets/stick
    - Sweet beverages: High juice fruit drinks, Regular fruit juice drinks, Other fruit-flavored drinks inc. flavored water, Regular blackcurrant diluting juice, No added-sugar diluting juice, Regular orange/lemon/other diluting juice, No added-sugar orange/lemon/other diluting juice, Regular fizzy drink

Sedentary behavior:

- **Time spent watching TV -** *3 years*.
    - "Hours/day child watches TV ***on week days*** before 6 pm" (None; <1; 1-2; 2-3; 3-4; more than 4); "Hours/day child watches TV ***on week days*** after 6 pm" (None; <1; 1-2; 2-3; 3-4; more than 4);
    - "Hours/day child watches TV ***on weekends*** before 6 pm" (None; <1; 1-2; 2-3; 3-4; more than 4); "Hours/day child watches TV ***on weekends*** after 6 pm" (None; <1; 1-2; 2-3; 3-4; more than 4).
- **Time spent using a computer -** 3 years. "How long spent playing on the computer?" (Up to 15 min a day; 16-30 min a day; 31-60 min a day; more than 60 min a day - please estimate);

Physical Activity:

- **Outdoors activities -** *3 years*.
    - "How long spent playing actively ***in the garden***?" (Up to 15 mins/day; 16-30 mins/day; 31-60 mins/day; More than 60 mins/day);
    - "In the last month, how long has your child spent ***at the park or playground*** when they have been?" (N/A, they haven't been; up to 15 minutes; 16-30 minutes; 31-60 minutes; more than 60 minutes).

Sleep:

"How many hours on average does (child's name) sleep in 24 hours? Please enter number of hours in boxes provided (this include any naps in a baby chair/buggy, etc.).

- **Amount of sleep per day -** *3 years*. Day time (6 am – 6 pm) (n Hours, no minutes).
- **Amount of sleep per night -** *3 years*. Night time (6 pm – 6am) (n Hours, no minutes).

EDEN (started 2003)

Diet:

- **FFQ (14 items used) -** *Available at 3 years old*.
    - Vegetables: cooked vegetables, raw vegetables
    - Fruit: fresh fruit, stewed fruit
    - Fish: fatty fish; non-fatty fish; breaded fish
    - Discretionary savory food: chips, salty biscuits
    - Discretionary sweet food: chocolate and sweets
    - Processed meat: cured meat, ham or poultry
    - Sweet beverages: sweet beverages; fruit juice

Sedentary behavior:

- **Time spent watching TV -** *3 years*. "Nowadays, how much time does your child spend watching TV or playing computer games?"
    - "***Usual week day***: hours", "minutes";
    - "***Usual Wednesday***: hours", "minutes";
    - "***Usual weekend day***: hours", "minutes".

Physical activity:

- **Outdoors activities -** *3 years*. "Nowadays, how much time does your child spend playing outside? (Garden, park, etc.)"
    - "***Usual weekday***: hours", "minutes";
    - "***Usual Wednesday***: hours", "minutes";
    - "***Weekend***: hours", "minutes".

Sleep:

- **Amount of sleep per day -** *3 years*. "Does your child regularly nap?" (Yes; No); "If yes, what is the usual length of a nap?" "hours; minutes".
- **Amount of sleep per night -** *3 years*.
    - "Most of the nights, at what time does your child ***go to bed***?" "hours and minutes";
    - "Most mornings, at what time does your child ***wake up***?" "hours and minutes".

ELFE (started: 2011)

Diet:

- **FFQ (11 items used)**. *Available at 2 years old*.
    - Vegetables: cooked vegetables, raw vegetables
    - Fruit: fresh fruit, stewed fruit
    - Fish: fish
    - Discretionary savory food: chips, salty biscuits
    - Discretionary sweet food: chocolate and sweets
    - Processed meat: cured meat
    - Sweet beverages: sweet beverages; fruit juice

Sedentary behavior:

- **Time spent watching TV -** *3.5 years*. "How much time does the child spend in front of a TV, at home or elsewhere?"
    - ***Usual weekday***: "hours", "minutes";
    - ***Usual Saturday***: "hours", "minutes";
    - ***Usual Sunday***: "hours", **"**minutes".
- **Time spent using a tablet -** *3.5 years*. "Does the child use a tablet at home at least once a week?" (Yes/no);
    - ***Usual weekday***: "hours", "minutes";
    - ***Usual Saturday***: "hours", "minutes";
    - ***Usual Sunday***: "hours", **"**minutes".
- **Time spent using a computer -** *3.5 years*. "Does the child use a computer at home at least once a week?" (Yes/no);
    - ***Usual weekday***: "hours", "minutes";
    - ***Usual Saturday***: "hours", "minutes";
    - ***Usual Sunday***: "hours", **"**minutes".
- **Time spent playing with a smartphone -** *3.5 years*. "Does the child use a computer at home at least once a week?" (Yes/no);
    - ***Usual weekday***: "hours", "minutes";
    - ***Usual Saturday***: "hours", "minutes";
    - ***Usual Sunday***: "hours", **"**minutes".
- **Time spent playing consoles (video games) -** *3.5 years*. "Does the child use a computer at home at least once a week?" (Yes/no);

- ***Usual weekday***: “hours”, “minutes”;
- ***Usual Saturday***: “hours”, “minutes”;
- ***Usual Sunday***: “hours”, **“**minutes”.

Physical Activity:

- **Outdoor activities -** *3.5 years*. “Nowadays, when the child isn’t at school or in vacation, how much time does he/she usually spend playing outside, if the weather is fair?”
  - ***Usual weekday***: “hours”, “minutes”;
  - ***Usual Saturday***: “hours”, “minutes”;
  - ***Usual Sunday***: “hours”, “minutes”.

Sleep:

- **Amount of sleep per day -** *3.5 years*.
  - “Does child nap during the week?” Yes; No -> “Usually, for how long?” Hours; Minutes.
  - “Does child nap during the week end or vacation?” (Yes; No) -> “Usually, for how long?”: Hours, Minutes.
- **Amount of sleep per night:**
  - ***Bed time* -** *3.5 years*. “What’s the child’s bed time? (***weekdays*** with class in the morning)” Hours, Minutes; “What’s the child’s bedtime (***week end and vacation***)?” Hours, Minutes.
  - ***Wake up time*** - *3.5 years*. “At what time does the child wake up (***weekdays*** with class in the morning)” Hours, Minutes. “At what time does the child wake up (***weekends and vacation***)” Hours, Minutes.

INMA (started 2003)

Diet:

- **FFQ (58 items used) -** *Available at 4 years old*.
    - Vegetables: lettuce, endive, escarole, cress, etc.; tomato in salad, as an accompaniment, crushed or with bread; tomato sauce, e.g. added to some dishes like egg, pasta, etc; onion, pureed leeks, creamed or other dishes (half small unit); onion (included in pureed or creamed); leeks (include in pureed or creamed),red or green pepper, raw or cooked (pureed or creamed); carrot, raw or cooked; boiled corn (cob or can); spinach or chard cooked; cabbage, cauliflower, broccoli cooked; Pumpkin cooked or in pureed (in-season); green beans cooked; aubergine, courgette (cooked not fried, included creamed or in pureed); olives; other legumes: peas or broad beans
    - Fruit: orange juice, included in and between meals; oranges, mandarins except in juices (in-season); banana; apple, pear; peaches, nectarine, apricot (in-season); Watermelon, melon (in-season); grapes (in-season); strawberry (in-season); cherry, plum, fig fresh (in-season); kiwi; natural pineapple, mango, papaya (in-season); fruit in syrup: e.g. peaches, pineaple, pear, fruit salad
    - Fish: Fish products (surimi, fish fillets); white fish fried or coat in batter (e.g. hake, sole, sea bream fresh or frozen); white fish (boiled, grilled); swordfish; other type of big/medium blue fish (e.g. tuna, bonito, salmon fresh or frozen); Small blue fish (e.g. anchovy, sardine, mackerel fresh or frozen); canned tuna (in water, drained); canned tuna (in oil, drained); calamari, baby cuttle fish, squid, cuttle fish, octopus; clam, mussel, cockle, etc; shellfish (prawn, crab, crayfish, lobster)
    - Discretionary savory food: crisps/chips; bag of popcorn, wheat snacks, tortilla chips, corn chips, etc.
    - Discretionary sweet food: Sugar (e.g. added in milk, yogurt); marmalade, honey; chocolate, bonbon or similar; chocolate powder; nesquik or similar; nutella or other chocolate creams; candies or other trifles, jelly beans, etc
    - Processed meat: sausages (Frankfurt style); sausages; catalan sausage, and other fresh sausages; Ham (cooked and cured); san jacobos (Breadcrumbed fried ham and cheese); cured turkey; cold cuts: salchichón, chorizo, fuet, salame, chóped, …; pâtés, foie gras; chicken or ham croquettes

- Sweet beverages: bottled fruit juice (between meals); bottled fruit juice (during meals); sugar-sweetened beverages (coke, orange or lemon soda) (1 small)

Sedentary behavior:

- **Time spent watching TV -** *4 years*. Time spent watching TV (hours/week).

Physical activity:

- **Outdoors activities:** Not available

Sleep:

- **Amount of sleep per day -** *4 years*. Time spent sleeping (hours/week).
- **Amount of sleep per night**: Same variable (can't differentiate between night and day).

MoBa (recruitment started in 1999)

Diet:

- **FFQ (15 items used) -** *Available at 3 years old*.
    - Vegetables: Cooked vegetables; Raw vegetables
    - Fruit: Fruit; Raisins
    - Fish: Fish filling (mackerel, caviar, etc.); Oily fish (salmon, herring, etc.), White fish (cod, coley, etc.); Fish pudding, fish cakes, fish balls, etc.
    - Discretionary savory food: Crisps, potato snacks
    - Discretionary sweet food: Jam, honey, chocolate spread, other sweet spread; Buns, cakes, waffles; Chocolate; Sweets, jelly babies, etc.
    - Processed meat: Meat filling (liver paste, ham, etc.)
    - Sweet beverages: Cordial / nectar / squash / fizzy drinks, sweetened

Sedentary behavior:

- **Time spent watching TV -** *3 years*. "How many hours on average does your child sit in front of a TV/video every day?" (4 hours or more; 3 hours; 1-2 hours; less than 1 hour; seldom/never).

Physical Activity:

- **Outdoor activities –** *3 years*. "How often is your child outside at present?" (Seldom; frequently, but less than 1 hour a day on average; 1-3 hours a day on average; more than 3 hours a day).

Sleep:

- **Amount of sleep during the day:** Not available.
- **Amount of sleep per night-** *5 years*. "Approximately how many hours does the child usually sleep per night on weekdays?" (8 hours or less; 9 hours; 10 hours; 11 hours; 12 hours or more).

Piccolipiù (started 2011)

Diet:

- **FFQ (11 items used) -** *Available at 4 years old*.
  - Vegetables: Vegetables (*defined as:* any vegetable excluded potatoes: raw vegetables, cooked vegetables and frozen vegetables, included those added in soups)
  - Fruit: Fruits (*defined as:* fruit or fresh fruit juice e.g. apple, pear, peach, apricot, banana, orange)
  - Fish: Fish (*defined as:* any type of fish either fresh or frozen)
  - Discretionary savory food: crackers/grissini
  - Discretionary sweet food**:** sugar; jam/honey; chocolate spread; Ice cream
  - Processed meat: processed meat (*defied as* ham, raw or cooked, or bresaola and other cold cuts)
  - Sweet beverages: packed fruit juices; sugar-sweetened beverages (e.g. Coke, Orange Soda, Cold Tea)

Sedentary Behavior:

- **Time spent watching TV -** *4 years*.
  - "***On weekdays*** on average how many hours a day does your child spend time watching television?" (never; <1hour; 1-1.999 hours; 2-2.999 hours; 3-4.999 hours; 4-5.999 hours; ≥5 hours; don't know);
  - "***On weekends and holidays*** on average how many hours a day does your child spend time watching television?" (never; <1hour; 1-1.999 hours; 2-2.999 hours; 3-4.999 hours; 4-5.999 hours; ≥5 hours; don't know);
- **Time spent using a tablet/smartphone/computer -** *4 years*.
  - "***On weekdays*** on average how many hours a day does your child spend / play in front of a computer or tablet or mobile phone?" (never; <1hour; 1-1.999 hours; 2-2.999 hours; 3-4.999 hours; 4-5.999 hours; ≥5 hours; don't know);
  - "***On weekends and holidays*** on average how many hours a day does your child spend / play in front of a computer or tablet or mobile phone?" (never; <1 hour ; 1-1.999 hours ; 2-2.999 hours; 3-4.999 hours; 4-5.999 hours; ≥5 hours; don't know);

Physical Activity:

- **Outdoors activities -** *4 years*. "Over the past weekend how long have your child been engaged in outdoor exercise?" (***Saturday***: …h …m; ***Sunday***: …h …m)

Sleep:

- **Amount of sleep per day -** *4 years*. "How many hours does the child sleep on average during the day?" (Hours/Minutes) -> (The reference is the last month).
- **Amount of sleep during the night -** *4 years*. "How many hours does the child sleep on average per night?" (Hours/Minutes) -> (The reference is the last month).

RHEA (started 2007)

Diet:

- **FFQ (18 items used):** *Available at 4 years old*.
    - Vegetables: green leafy vegetables; cabbages; fruiting vegetables; root vegetables
    - Fruit: citrus fruits; miscellaneous fruits; berries; fruits with B carotene; dry fruits; fresh fruit juice
    - Fish: fatty fish, non-fatty fish, sea food,
    - Discretionary savory food: not available
    - Discretionary sweet food: sugar, sugar products
    - Processed meat: processed meat products
    - Sweet beverages: soft drinks; packed fruit juice

Sedentary behavior:

- **Time spent watching TV:** Time spent watching television in hours per usual day? (continuous, originally asked separately for weekdays and weekends)

Physical activity:

- **Outdoors activities:** How much time on average does the child spend: outdoors? (continuous, originally asked separately for weekdays and weekends)

Sleep:

- **Amount of sleep per day -** *4 years*. "Mean time of sleep during the daytime (mins)", "How many hours in total does the child sleep during a usual day?"
- **Amount of sleep per night -** *4 years*. "Mean hour of sleep (hours)"; "How many hours in total does the child sleep during a usual day (24-hour period)?"

SWS (started 1998)

Diet:

- **FFQ (23 items used) -** *Available at 3 years old.*
    - Vegetables: vegetables
    - Fruit: fruit; other fruit; pure fruit juice; extra pure fruit juice
    - Fish: fish and shellfish; fish in batter; other white fish; oily fish
    - Discretionary savory food: baby food savory snacks; crisps; crackers
    - Discretionary sweet food: teaspoons of sugar; jams and sweet spreads; chocolate and digestive biscuits; chocolate; ice cream; ice lollies frequency; sweets frequency; other biscuits
    - Processed meat: processed meat
    - Sweet beverages: high energy soft drink; low calorie soft; pure fruit juice

Sedentary behavior:

- **Time spent watching TV -** *3 years*. "On a typical day, how many hours does he/she generally spend watching television?" (More than 5 hours; 4-5 hours; 3-4 hours; 2-3 hours; 1-2 hours; less than 1hour; none).

Physical Activity:

- **Outdoors activities -** *4 years.* "Average time child spends outdoors per day" (n hours).

Sleep:

- **Amount of sleep per day -** *3 years*. "On the days he/she naps, what is the **total time** spent napping during the day?" (hours + min /60)
- **Amount of sleep per night -** *3 years*.
    - "What time does the study child generally ***go to sleep*** at night? (24hr clock)" (hours + min/60);
    - **"**What time does he/she generally ***wake up*** in the morning? (24hr clock)" (hours + min/60).

Supplementary material 4. Cohort-specific anthropometric measurements.

Cohort	Source of anthropometrics (all ages)
ALSPAC 1991	Weight and height measures were obtained from numerous sources from birth to 18 years, including from midwives, health visitors, linkage to child health records, and ALSPAC research clinics. Birth weight/length data were available from obstetric records. Child health records were used for measures up to 4 years. ALSPAC research clinics were used for measures from 4 to 18 years.
BiB 2007	Maternity records; BiB cohort and sub-cohort studies; Healthy Child Programme; General practitioner (GP), National Child Measurement Programme
EDEN 2003	Measured at clinical examinations (birth to 5 years) and collected from GP reports on child's health booklets
ELFE 2011	Collected from GP reports on child's health booklets
INMA 2003	Measured in a clinical setting
MoBa 1999	Parent-report based on health cards (6 weeks, 3-18 months), and parent-reported (2-8 years)
Piccolipiù 2011	Measured
RHEA 2003	Child anthropometric measures were taken by specially trained research assistants according to standard procedures at the University Hospital of Heraklion, Crete, Greece
SWS 1998	Measurements of children by research nurses (at birth, 6, 12, 24 months, 3-4 years, 6 years, 8 years)

ALSPAC, Avon Longitudinal Study of Parents and Children; BiB, Born in Bradford; EDEN, Étude des Déterminants pré et postnatals du développement et de la santé de l'Enfant; ELFE, Etude Longitudinale Française depuis l'Enfance; INMA, INfancia y Medio Ambiente; MoBa, Norwegian Mother, Father and Child Cohort Study; SWS, Southampton Women's Survey.

Supplemental material 5. Distribution of EBRBs in the European birth and pregnancy cohorts included in the lifestyle pattern analysis.

	Vegetables[1]	Fruit[1]	Fish[1]	Discretionary savory foods[1]	Discretionary sweet foods[1]	Processed meat[1]	Sweet beverages[1]	TV time[2]	Other screen time[2]	Outdoor play time[3]	Sleep time duration[2]
ALSPAC, 1991 (n*=10 595)	1.36 (0.89)	1.11 (0.71)	0.37 (0.29)	0.45 (0.31)	2.03 (1.21)	0.16 (0.15)	0.25 (0.44)	1.46 (0.72)	NA	0 (1)	11.51 (0.93)
Missing data, n (%)	3019 (23.4)	4697 (36.4)	2952 (22.9)	2832 (21.9)	4142 (32.1)	2877 (22.3)	3961 (30.7)	2954 (22.9)	NA	3134 (24.3)	3455 (26.8)
BiB, 2007 (n*=1 168)	2.87 (2.22)	4.75 (3.28)	0.63 (0.55)	1.11 (0.94)	1.44 (1.33)	0.28 (0.33)	2.05 (2.38)	1.91 (1.65)	0.39 (0.64)	0 (1)	11.88 (1.16)
Missing data, n (%)	12 (1.0)	12 (1.0)	12 (1.0)	12 (1.0)	12 (1.0)	16 (1.4)	12 (1.0)	10 (0.9)	685 (58.6)	519 (44.4)	3 (0.3)
EDEN, 2003 (n*=1 321)	1.02 (0.78)	1.23 (0.75)	0.35 (0.33)	0.13 (0.19)	0.47 (0.42)	0.61 (0.40)	0.72 (0.71)	1.10 (0.86)	NA	0 (1)	12.59 (0.96)
Missing data, n (%)	14 (1.1)	15 (1.1)	16 (1.2)	12 (0.9)	14 (1.1)	13 (1.0)	14 (1.1)	160 (12.1)	NA	175 (13.2)	102 (7.7)
ELFE, 2011 (n*=11 623)	1.44 (0.85)	1.72 (0.95)	0.28 (0.23)	0.10 (0.18)	0.33 (0.43)	0.10 (0.21)	0.60 (0.73)	0.87 (0.81)	0.30 (0.57)	0 (1)	12.33 (0.74)
Missing data, n (%)	166 (1.4)	164 (1.4)	166 (1.4)	167 (1.4)	167 (1.4)	166 (1.4)	165 (1.4)	46 (0.4)	34 (0.3)	1871 (13.9)	1539 (13.2)
INMA, 2003 (n*=1 584)	1.45 (0.82)	1.74 (1.25)	0.59 (0.29)	0.24 (0.20)	2.63 (1.89)	0.79 (0.36)	0.50 (0.70)	1.48 (0.90)	NA	NA	10.38 (0.97)
Missing data, n (%)	73 (4.6)	73 (4.6)	73 (4.6)	73 (4.6)	73 (4.6)	73 (4.6)	73 (4.6)	17 (1.1)	NA	NA	9 (0.06)
MoBa, 1999 (n*=57 597)	0.73 (0.36)	1.70 (0.8)	0.87 (0.58)	0.19 (0.08)	1.00 (0.46)	0.98 (0.70)	0.39 (0.50)	0.93 (0.63)	NA	0 (1)	10.58 (0.69)
Missing data, n (%)	711 (1.2)	699 (1.2)	2147 (3.7)	367 (0.6)	1121 (1.9)	381 (0.7)	684 (1.2)	273 (0.5)	NA	230 (0.4)	36274 (62.8)
Piccolipiù, 2011 (n*=2 258)	0.9 (0.69)	1.70 (1.21)	0.24 (0.21)	0.17 (0.23)	1.19 (0.97)	0.26 (0.21)	0.55 (0.72)	1.61 (0.83)	0.48 (0.55)	0 (1)	10.24 (0.97)
Missing data, n (%)	125 (5.5)	241 (10.7)	111 (4.9)	139 (6.2)	155 (6.9)	120 (5.3)	134 (5.9)	28 (1.7)	27 (1.2)	280 (12.4)	115 (5.1)
RHEA, 2003 (n*=1 086)	2.41 (1.39)	1.89 (1.06)	0.17 (0.11)	NA	2.51 (1.49)	0.24 (0.25)	0.39 (0.36)	1.32 (0.94)	NA	0 (1)	10.8 (1.22)
Missing data, n (%)	46 (4.2)	47 (4.2)	44 (4.1)	NA	47 (4.2)	43 (4.0)	47 (4.2)	229 (21.1)	NA	517 (47.6)	229 (21.1)
SWS, 1998 (n*=2 625)	1.91 (0.98)	5.71 (3.45)	0.53 (0.36)	0.72 (0.44)	1.80 (1.06)	0.89 (0.46)	2.24 (2.05)	1.76 (0.96)	NA	0 (0.99)	11.57 (0.9)
Missing data, n (%)	27 (1.0)	27 (1.0)	27 (1.0)	29 (1.1)	27 (1.0)	31 (1.2)	27 (1.0)	88 (3.4)	NA	1466 (55.8)	1145 (43.6)

NA: not available
If not otherwise stated, values are expressed as means (SD)
*number of children with no missing data for at least one of the EBRBs studied
[1] times/day; [2] hours/day; [3] standardized by season

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