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Perinatal and lifestyle factors mediate the association between maternal education and preschool children's weight status: the ToyBox study

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ABSTRACT

Objective: This study aimed to explore the associations among perinatal, sociodemographic, and behavioral factors and preschool overweight/obesity.
Methods: Data were collected from 7541 European preschoolers in May/June 2012. Children's anthropometrics were measured, and parents self-reported all other data via questionnaires. Level of statistical significance was set at $P \leq 0.05$.
Results: Certain perinatal factors (i.e., maternal prepregnancy overweight/obesity, maternal excess gestational weight gain, excess birth weight, and "rapid growth velocity"), children's energy balance–related behaviors (i.e., high sugar-sweetened beverage consumption, increased screen time, reduced active-play time), family sociodemographic characteristics (i.e., Eastern or Southern Europe, low maternal and paternal education), and parental overweight/obesity were identified as correlates of preschoolers' overweight/obesity. Furthermore, maternal prepregnancy overweight/obesity, children's "rapid growth velocity," and increased screen time mediated by 21.2%, 12.5%, and 5.7%, respectively, the association between maternal education and preschoolers' body mass index.
Conclusion: This study highlighted positive associations of preschooler's overweight/obesity with excess maternal prepregnancy and gestational weight gain, excess birth weight and "rapid growth velocity," Southern or Eastern European region, and parental overweight/obesity. Moreover, maternal prepregnancy overweight/obesity, children's "rapid growth velocity," and increased screen time partially mediated the association between maternal education and preschoolers' body mass index. The findings of the present study may support childhood obesity prevention initiatives, because vulnerable population groups and most specifically low-educated families should be prioritized. Among other fields, these intervention initiatives should also focus on the importance of normal prepregnancy maternal weight status, normal growth velocity during infancy, and retaining preschool children's screen time within recommendations.

The authors declare that they have no conflict of interest.

All authors contributed to the conception and design of the ToyBox study; generation, collection, assembly, analysis and interpretation of data; drafting the manuscript; and revising it critically. O.A. wrote the manuscript.

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Introduction

Epidemiological studies recording the magnitude of overweight and obesity among preschool children in Europe remain scarce. A limited number of available studies indicate an increasing trend in the prevalence of overweight and obesity in preschool years. Moreover, evidence suggests that there are marked differences in this trend among socioeconomic groups and regions across Europe, as well as among families with overweight/obese parents [1–3]. In addition, previous studies have further highlighted the multifactorial etiology of obesity in preschool childhood, with several risk factors reported to exert their effect on the manifestation of the obesity phenotype from very early developmental stages, such as during the perinatal period or through energy balance–related behaviors (EBRBs) adopted in the preschool years [4–7].

Perinatal factors have been reported to exert their effect either before or during the intrauterine period as well as during infancy and may lead to permanent physiological changes and the so-called metabolic programming that can influence weight status in early childhood but also later life [8]. Still, perinatal factors seem to have a sociodemographic dimension. In this regard previous studies have reported that increased maternal prepregnancy obesity and excess gestational weight gain, maternal smoking during pregnancy, infant formula feeding, and early introduction of solid foods during the weaning period are influenced by maternal education, family economic status, and ethnicity [9–11].

Regarding EBRBs, consumption of energy-dense foods, low levels of physical activity, and increased sedentary time have been reported to be independently associated with an increased childhood obesity risk [12,13]. Similar to perinatal risk factors, EBRBs seem to be influenced also by regional and sociodemographic variations [7,14]. This observation could be further supported by recent findings from the ToyBox study, indicating unhealthier EBRBs in southern European countries, with Greek preschool children having significantly lower physical activity levels and, at the same time, significantly more time spent on sedentary activities compared with their peers in central/northern European countries [6]. Furthermore, the ToyBox study has also found that maternal education is positively associated with children's diet quality, with children of lower-educated mothers having lower diet quality compared with children whose mother had higher education [15]. Still, the interplay among perinatal risk factors, EBRBs during preschool years, and family sociodemographic characteristics and other parental characteristics, such as their excess weight status, in the development of childhood overweight/obesity remains unclear.

Studies examining the associations of perinatal factors, preschoolers' EBRBs, and sociodemographic indices with overweight/obesity in preschool children in Europe are limited, with data in most cases originating from single countries. Moreover, studies examining the mediating role of perinatal and later EBRBs on the association between sociodemographic indices and children's weight status are currently lacking in the literature.

Considering this lack of evidence, the first aim of the present study was to explore the associations among perinatal factors, family sociodemographic characteristics, parental overweight/obesity, and children's EBRBs with overweight/obesity in preschoolers from six countries in Southern, Eastern, and Central/Northern Europe. A second aim was also to examine the potential mediating roles of perinatal factors and EBRBs in the associations between children's body mass index (BMI) and those family sociodemographic and/or parental characteristics for which the statistical significance of their association with preschooler's overweight/obesity was lost after controlling for perinatal factors and preschooler's EBRBs.

Materials and methods

The ToyBox study (www.toybox-study.eu) adhered to the Declaration of Helsinki and the conventions of the Council of Europe on human rights and biomedicine. All countries (Belgium, Bulgaria, Germany, Greece, Poland, and Spain) obtained ethical clearance from the relevant ethical committees and local authorities and all parents/caregivers provided a signed consent form before being enrolled in the study.

A detailed description of the ToyBox study design is provided elsewhere [16]. In brief, the study sample was composed of preschool children and their families, who were approached via kindergartens recruited from three socioeconomic levels of municipalities within each country. All data presented in the present study were obtained between May and June 2012, using standard methods and equipment.

Two consecutive measurements of children's weight to the nearest 100 g using electronic scales (types SECA 861 and SECA 813; Seca, Hamburg, Germany) and height to the nearest 0.1 cm using a portable stadiometer (types SECA 225 and SECA 214; Seca) were taken. Before the anthropometric measurements, children removed their shoes, wet nappies, jewelry, hair ornaments, braids, and heavy clothing, and during the measurements, children were asked to stand still in an erect position. BMI z-scores were calculated with the use of LMS method and children were categorized as normal weight or overweight/obese [17]. Moreover, the World Health Organization ANTHRO-PLUS software was used to estimate the BMI-for-age percentile for each child (http://www.who.int/growthref/tools/en/).

Family, sociodemographic, perinatal, and behavioral data were reported by parents and caregivers via questionnaires. Specifically, parents and caregivers self-reported their years of education (excluding any potential grade retention during compulsory education), their weight and height, and their child's sex. Regarding the perinatal data, in line with previous studies conducted in this field, parents were asked to obtain all available information (e.g., child's weight at birth and at 6 and 12 mo of age) from their child's medical record. All other perinatal information (i.e., maternal prepregnancy weight status, smoking during pregnancy, maternal gestational age, and feeding practices during the first 6 mo of age) were reported by the parents. Maternal prepregnancy weight status was calculated based on mother's self-reported weight before pregnancy (2–3 mo before conception) and current height and categorized as normal weight (BMI ≤24.9 kg/m^2) or overweight/obese (BMI >25 kg/m^2). Maternal self-reported weight gain during pregnancy was converted into *within Institutes of Medicine (IOM) recommendations*, *more than IOM recommendations*, or *less than IOM recommendations* based on the criteria of the IOM [18]. Maternal smoking during gestation was self-reported and categorized as smoking or no smoking, meaning smoking or not during any trimester, respectively. According to their birth weight and gestational age, children were categorized as small for gestational age (SGA: < 10th percentile), appropriate for gestational age (AGA: 10th–89th percentile), or large for gestational age (LGA: ≥ 90th percentile) based on the World Health Organization growth charts. According to their gestational age, children were grouped as preterm or full-term (if born <37 wk or ≥37 wk of gestation, respectively). Change in weight-for-length z score from birth to 6 and 12 mo of age was calculated and children's weight gain during their first year of age was categorized as poor (<−1 z score), average (<−1 to >+1 z score), or rapid (>+1 z score). Finally, children were categorized according to their feeding practices during the first 6 mo of age as exclusive or non-exclusive breastfeeding, if they were breastfed exclusively or if they received foods (e.g., formula milk) instead of or in parallel with breastfeeding.

Regarding the behavioral data, parents and caregivers completed a semiquantitative food frequency questionnaire (FFQ), in which they described their children's consumption of foods and beverages over the last 12 mo. This FFQ was developed based on a previously validated FFQ [19]. More information about the FFQ can be found elsewhere [20]. For the needs of the present study, consumption of fruit and vegetables (in grams per day, which were dichotomized to ≥400 g/d and <400 g/d according to the European Food Information Council recommendations), sweets (in grams per day), and sugar-sweetened beverages (including sugared soft drinks, sugared prepacked fruit juices, and chocolate/sugared milk; in milliliters per day, which were converted to tertiles) was used as an indicator of preschoolers' energy intake, and active play (in hours per day, which were converted to tertiles) and screen time (in hours per day, which were dichotomized to ≥1 h/d and <1 h/d according to the Australian and Canadian recommendations) were used as indicators of their energy expenditure and sedentary time, respectively.

Categorical variables were summarized as relative frequencies (%). To examine the associations of perinatal, sociodemographic, and behavioral indices with overweight/obesity, logistic regression analyses (univariate and multivariate) were performed. To test the hypothesis that perinatal and lifestyle factors mediate the

association of maternal education with preschool overweight/obesity, we performed mediation analyses, using one exposure variable (i.e., maternal education) and preschooler's weight status as the main outcome. All analyses were conducted with the Statistical Package for Social Sciences (Version 21, IBM Corp., Armonk, NY, USA). $P < 0.05$ was set as level of significance.

Results

Descriptive data

Population characteristics are shown in Table 1. A total sample of 7541 preschool children and their parents and caregivers participated in the study. Participants were almost equally distributed among the three regions—Central/Northern Europe (Belgium and Germany: 33.2%), Southern Europe (Greece and Spain: 35.1%), and Eastern Europe (Bulgaria and Poland: 31.7%). Mean (SD) child age was 4.7 (0.44) years and 48.0% of the sample were girls. Mean (SD) age of the participating mothers was 35.40 (4.8) years. The prevalence of overweight/obesity among children was found to be significantly higher in girls compared with boys (17.1% versus 12.4%, respectively, $P < 0.001$), and the prevalence of overweight/obesity observed among mothers before pregnancy was 17.3%. A percentage of children were found to have several perinatal risk factors (e.g., only 15.9% of children were exclusively breastfed until the sixth month of age, 20.3% had rapid weight gain during the first 6 mo of age, etc.).

Table 1
Descriptive data of preschool children and their parents/caregivers ($n = 7541$) from six European countries: The ToyBox study

	Cases (%)
European Region	
Eastern Europe (Bulgaria & Poland)	2391 (31.7)
Central/Northern Europe (Belgium & Germany)	2506 (33.2)
Southern Europe (Greece & Spain)	2644 (35.1)
Sex	
Boys	3919 (52.0)
Girls	3622 (48.0)
Weight status in boys	
Normal	3431 (87.6)
Overweight/obese	487 (12.4)
Weight status in girls	
Normal	3002 (82.9)
Overweight/obese	619 (17.1)
Maternal prepregnancy weight status	
Normal	5668 (82.7)
Overweight/obese	1184 (17.3)
Gestational weight gain	
Within IOM recommendations	2355 (35.0)
Less than IOM recommendations	1851 (27.5)
More than IOM recommendations	2515 (37.4)
Maternal weight status	
Normal	5222 (73.5)
Overweight/obese	1885 (26.5)
Paternal weight status	
Normal	2318 (37.5)
Overweight/obese	3865 (62.5)
Maternal education level	
Low	2884 (39.6)
Mid/high	4393 (60.4)
Paternal education level	
Low	2994 (46.1)
Mid/high	3497 (53.9)
Maternal smoking during pregnancy	
No smoking	6111 (86.2)
Smoking	975 (13.8)
Breastfeeding	
Non-exclusive	6146 (84.1)
Exclusive	1162 (15.9)
Birth weight for gestational age	
Appropriate (10th–89th percentile)	6431 (92.8)
Small (<10th percentile)	358 (5.2)
Large (>90th percentile)	139 (2.0)
Gestational age	
Full-term (≥37 wk)	6116 (89.6)
Preterm (<37 wk)	708 (10.4)
Weight gain in the first 6 mo	
Average (−1 to +1 z-score change)	3580 (60.7)
Poor (<−1 z-score change)	1120 (19.0)
Rapid (>+1 z-score change)	1197 (20.3)

IOM, Institute of Medicine 2009 report.

Associations among perinatal and sociodemographic factors, EBRBs, and children's weight status

Table 2 presents the associations among perinatal and sociodemographic factors, EBRBs, and overweight/obesity in preschool children in one univariate model and one multivariate model. In the univariate analysis, it was observed that most sociodemographic factors (all except for parental nationality) and perinatal factors (all except for breastfeeding and gestational age) and some of the EBRBs were associated with children's overweight/obesity. However, some of these associations did not remain significant when all factors (sociodemographic and perinatal factors and EBRBs) were included in one regression model. More specifically, according to the results of the multivariate regression analysis, living in Eastern or Southern Europe (odds ratio [OR] 1.51, 95% confidence interval [CI] 1.07–2.12, and OR 2.34, 95% CI 1.70–3.24, respectively), maternal overweight/obesity (OR 1.42, 95% CI 1.07–1.88), and paternal overweight/obesity (OR 1.55, 95% CI 1.23–1.97) were the only sociodemographic factors that were found to be associated with overweight/obesity in preschoolers. Regarding the perinatal factors, maternal prepregnancy overweight/obesity (OR 1.52, 95% CI 1.10–2.09), LGA (OR 2.59, 95% CI 1.36–4.94), rapid weight gain during the first 6 mo of life (OR 1.58, 95% CI 1.23–2.04), and exceeding the IOM-recommendations regarding gestational weight gain (OR 1.26, 95% CI 1.00–1.61) were found to be significantly associated with overweight/obesity. Regarding the later EBRBs, high sugar-sweetened beverages consumption (≥210.7 mL/d) was the only lifestyle factor found to be associated with overweight/obesity at this age.

Mediation analyses

The mediation models examined in the present study are presented in Figure 1.

Table 3 and Table 4 show the results derived by the mediation analyses. The outcomes indicated that path c and path a × b were statistically significant only in the cases reported next.

More specifically, when examining perinatal factors as potential mediators in the association between maternal education and children's BMI for age percentile, it was found that maternal education was significantly associated with maternal prepregnancy weight status (path a) and maternal prepregnancy weight status with children's BMI for age percentile (path b), whereas maternal education was significantly associated with children's BMI for age percentile (path c). The proportion mediated by maternal prepregnancy weight status in the association between maternal education and children's BMI for age percentile was 21.2%. Similar associations in paths a, b, and c were identified when rapid growth velocity during the first 6 mo was used as a potential mediator in the association between maternal education and children's BMI for age percentile. In this case, the proportion mediated by rapid growth velocity during the first 6 mo was 12.5%.

Table 2
Associations between perinatal factors and prevalence of overweight/obesity in preschool children ($n = 4375$) from six European countries: The ToyBox study

		Univariate analysis	Multivariate analysis
		OR (95% CIs)	OR (95% CIs)
Sociodemographic factors			
Maternal education level	Medium/high (>14 y of education)	1.00	1.00
	Low (≤14 y of education)	**1.50 (1.32–1.72)**	1.23 (0.96–1.60)
Paternal education level	Medium/high (>14 y of education)	1.00	1.00
	Low (≤14 y of education)	**1.34 (1.17–1.54)**	1.03 (0.81–1.32)
Parental nationality	Both parents native	1.00	1.00
	At least one parent non-native	1.11 (0.92–1.33)	0.97 (0.70–1.36)
Region	Central/Northern (Belgium, Germany)	1.00	1.00
	Eastern (Poland, Bulgaria)	**1.30 (1.10–1.54)**	**1.51 (1.07–2.12)**
	Southern (Greece, Spain)	**1.88 (1.60–2.20)**	**2.34 (1.70–3.24)**
Maternal weight status	Normal weight	1.00	1.00
	Overweight/obese	**1.84 (1.60–2.12)**	**1.42 (1.07–1.88)**
Paternal weight status	Normal weight	1.00	1.00
	Overweight/obese	**1.91 (1.62–2.24)**	**1.55 (1.23–1.97)**
Perinatal factors			
Maternal prepregnancy weight status	Normal weight	1.00	1.00
	Overweight/obese	**2.05 (1.74–2.41)**	**1.52 (1.10–2.09)**
Gestational weight gain	Within IOM recommendations	1.00	1.00
	Less than IOM recommendations	0.89 (0.74–1.08)	0.87 (0.66–1.15)
	More than IOM recommendations	**1.48 (1.26–1.73)**	**1.26 (1.00–1.61)**
Maternal smoking during pregnancy	No smoking	1.00	1.00
	Smoking	**1.53 (1.28–1.82)**	1.14 (0.84–1.55)
Breastfeeding	Non-exclusive	1.00	
	Exclusive	0.97 (0.79–1.19)	
Birth weight for gestational age	Appropriate (10th–89th percentile)	1.00	1.00
	Small (<10th percentile)	0.74 (0.53–1.04)	0.64 (0.38–1.10)
	Large (>90th percentile)	**2.19 (1.49–3.20)**	**2.59 (1.36–4.94)**
Gestational age	Preterm (<37 wk)	1.00	
	Full-term (≥37 wk)	1.16 (0.92–1.47)	
Weight gain in the first 6 mo	Average (−1 to +1 z-score change)	1.00	1.00
	Poor (<−1 z-score change)	**0.68 (0.54–0.84)**	**0.62 (0.45–0.86)**
	Rapid (>+1 z-score change)	**1.49 (1.26–1.77)**	**1.58 (1.23–2.04)**
EBRBs			
Fruit and vegetables	Within recommendations (≥400 g/d)	1.00	1.00
	Less than recommendations (<400 g/d)	0.92 (0.79–1.07)	0.91 (0.72–1.15)
Sugar sweetened beverages	First tertile (≤64.3 mL/d)	1.00	1.00
	Second tertile (>64.3 to <210.7 mL/d)	1.04 (0.87–1.23)	1.13 (0.87–1.46)
	Third tertile (≥210.7 mL/d)	0.98 (0.83–1.16)	**1.37 (1.04–1.81)**
Sweets and salty snacks	g/d	1.00 (0.99–1.00)	1.00 (0.99–1.00)
Active play	First tertile (≤1.75 h/d)	1.00	1.00
	Second tertile (>1.75 to <3.21 h/d)	0.89 (0.76–1.04)	0.81 (0.63–1.04)
	Third tertile (≥3.21 h/d)	**0.71 (0.61–0.84)**	0.79 (0.61–1.03)
Screen time	Within recommendations (<1 h/d)	1.00	1.00
	More than recommendations (≥1 h/d)	**1.45 (1.25–1.68)**	1.05 (0.82–1.33)

BMI, body mass index; CI, confidence interval; EBRB, energy balance–related behavior; IOM, Institute of Medicine; OR, odds ratio.
Statistically significant odds ratios are highlighted in bold. Sugar-sweetened beverages include sugared soft drinks, sugared prepacked fruit juices and sugared/chocolate milk. Multivariate model: Included all perinatal factors found to be associated with preschool overweight/obesity at univariate analysis, all sociodemographic factors and all EBRBs examined in this study and preschoolers' age and sex.

When examining EBRBs as potential mediators in the association between sociodemographic indices (maternal education) and children's BMI for age percentile, it was found that maternal education was significantly associated with children's screen time (path a) and children's screen time with children's BMI for age percentile (path b), whereas maternal education was significantly associated with children's BMI for age percentile (path c). The proportion mediated by children's active play in the association between maternal education and children's BMI-for age percentile was 5.7%.

Discussion

The present study aimed to explore the associations among perinatal factors, preschoolers' EBRBs, family sociodemographic characteristics, and parental overweight/obesity in relation to overweight/obesity in preschool children. Considering that maternal education has been repeatedly reported by several previous studies as the sociodemographic index most strongly associated with overweight and obesity in children [21] and the loss of statistical significance in the association between maternal education and preschoolers' overweight/obesity in the present study, after controlling for perinatal factors and preschoolers' EBRBs, a second aim of the present study was to examine the potential mediating effect of perinatal factors and EBRBs in the aforementioned association.

Regarding the first aim, the results of the present study indicated that region and parental overweight/obesity were found to be associated with preschoolers' overweight/obesity. These findings are in line with previous studies indicating a north-south

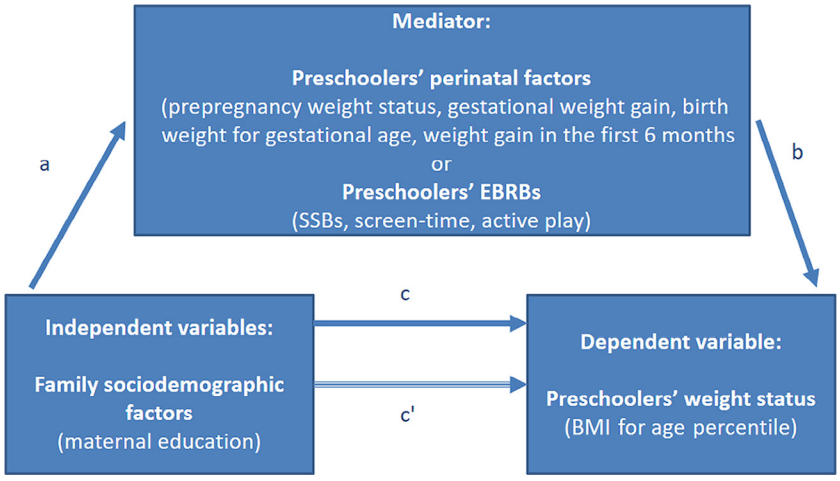

Fig. 1. Mediation model examined in the present study (sociodemographic factors [independent variable], preschoolers' perinatal factors or EBRBs [mediator], BMI-for age percentile [dependent variable]). BMI, body mass index; EBRBs, energy balance–related behaviors; SSBs, sugar-sweetened beverages.

gradient of childhood obesity, with children living in Northern Europe having lower prevalence rates of overweight and obesity compared with their peers from Southern Europe [22]. In addition, children with overweight or obese parents are also at a higher likelihood for being overweight/obese compared with children with normal-weight parents, which is probably attributed to the heredity of parental obesity as well as to the obesogenic environment that overweight/obese parents create and sustain for

Table 3
Association between sociodemographic factors (maternal education) and preschoolers' BMI-for age percentile and the potential mediating effect of preschoolers' perinatal factors

	a	SE	b	SE	c	SE	c′	SE	(a) × (b)	SE	95% CI of (a) × (b)	Mediated effect
Mediator: Maternal prepregnancy weight status (1: overweight/obese; 2: normal weight)												
Maternal education (1: ≤14 y of education; 2: >14 y of education)	**0.712**	**0.103**	**–8.205**	**0.934**	**–2.750**	**0.729**	**–2.166**	**0.727**	**–0.584**	**0.115**	**–0.829;–0.387**	21.2
Mediator: Gestational weight gain (1: more than IOM recommendations; 2: within/less than recommendations)												
Maternal education (1: ≤14 y of education; 2: >14 y of education)	**–0.028**	**0.013**	0.798	0.749	**–2.792**	**–0.737**	**–2.770**	**0.737**	–0.023	0.026	–0.097;0.012	
Mediator: Birth weight for gestational age (1: LGA; 2: AGA/SGA)												
Maternal education (1: ≤14 y of education; 2: >14 y of education)	–0.006	0.004	**–12.079**	**2.451**	**–2.686**	**0.731**	**–2.756**	**0.730**	0.701	0.048	–0.015;0.175	
Mediator: Weight gain in the first 6 mo (1: rapid weight gain; 2: average/retarded weight gain)												
Maternal education (1: ≤14 y of education; 2: >14 y of education)	**0.045**	**0.012**	**–8.795**	**0.990**	**–2.839**	**0.800**	**–2.444**	**0.795**	**–0.395**	**0.114**	**–0.634;–0.181**	12.5

AGA, appropriate for gestational age; CI, confidence interval; IOM, Institutes of Medicine; LGA, large for gestational age; SE, standard error; SGA, small for gestational age.
Values highlighted in bold indicate significance.

Table 4
Association between sociodemographic factors (maternal education) and preschoolers' BMI-for-age percentile and the potential mediating effect of preschoolers' EBRBs

	a	SE	b	SE	c	SE	c′	SE	(a) × (b)	SE	95% CI of (a) × (b)	Mediated effect
Mediator: Sugar-sweetened beverages (1: third quartile; 2: first and second quartiles)												
Maternal education (1: ≤14 y of education; 2: > 14 y of education)	–0.020	0.014	0.741	0.792	**–2.270**	**0.790**	**–2.255**	**0.790**	–0.015	0.023	–0.081; 0.015	
Mediator: Screen time (1: More than recommendations (≥1 h/d); 2: Within recommendations (<1 h/d))												
Maternal education (1: ≤14 y of education; 2: > 14 y of education)	**0.058**	**0.013**	**–2.758**	**0.740**	**–2.780**	**0.721**	**–2.621**	**0.723**	**–0.159**	**0.055**	**–0.293; –0.069**	5.7
Mediator: Active play (1: third quartile; 2: first and second quartiles)												
Maternal education (1: ≤14 y of education; 2: >14 y of education)	0.005	0.013	1.307	0.746	**–2.938**	**0.733**	**–2.945**	**0.733**	0.007	0.019	–0.024; 0.062	

BMI, body mass index; CI, confidence interval; EBRB, energy balance–related behaviors; SE, standard error.
Values highlighted in bold indicate significance.

themselves and their children [22]. Regarding the perinatal factors examined in this study, maternal prepregnancy overweight/obesity, excess gestational weight gain, maternal smoking during pregnancy, increased birth weight for gestational age, and rapid weight gain in the first 6 mo of life were significantly associated with preschoolers' overweight/obesity. The associations reported in the present study between perinatal factors and children's overweight/obesity have been confirmed by other studies but mainly for school-aged children and adolescents, whereas the relevant data on preschool children are limited [4,23–25]. We also did not find any significant association between exclusive breastfeeding and overweight/obesity, which is in line with the systematic review of systematic reviews by Patro-Gołąb et al. [26] and indicates that in addition to feeding practices during infancy (i.e., breastfeeding or formula feeding) there are also other EBRBs occurring after the initiation of complementary feeding that may exert an equally significant effect on children's weight status. Regarding the EBRBs assessed in our study, the time preschoolers spend engaged in active play and screen-related activities were found to be associated with preschoolers' overweight/obesity, a finding that has also been confirmed by other previous studies conducted with preschool children [6,27].

The associations of preschoolers' overweight and obesity with region and parental weight status retained their statistical significance after controlling for perinatal factors and children's EBRBs. The implication of this observation is that these associations were independent from perinatal factors and preschoolers EBRBs. However, this was not observed in the associations of preschoolers' overweight/obesity with paternal and maternal education, which became statistically insignificant after controlling for perinatal factors and children's EBRBs, thus indicating a most likely mediating role of perinatal factors and EBRBs in the aforementioned associations.

To explore the potential mediating role of perinatal factors and preschoolers' EBRBs, several mediation analyses were performed. The results from the mediation models tested indicated that less educated mothers are at higher risk of having overweight or obese preschool children, and this association is partially mediated by maternal prepregnancy overweight/obesity, children's rapid weight gain during the first 6 mo of their lives, and increased screen time. The interpretation is that because lower education is linked to overweight and obesity, these women are most likely to enter pregnancy being overweight or obese and as such give birth to large-for-gestational-age infants and sustain an obesogenic environment for their children, which progressively leads to increased BMI at preschool years [28]. In addition, mothers of lower education are more likely to overfeed their children during infancy, as they have been previously reported to have difficulties in correctly perceiving the concept of normal growth and normal weight status in their children [29], which consequently leads infants to rapid growth velocity. Rapid growth velocity during infancy has been consistently been reported by many previous studies as a strong early risk factor of childhood obesity and related comorbidities in adulthood [23]. Lastly, mothers of lower education have been previously reported not to set any rules to control the time their young children are engaged in screen-related activities (e.g., TV watching) because this is usually a convenient way of babysitting or calming down their children [30]. Increased screen time, however, is among the EBRBs that have been most strongly associated with overweight and/or obesity in various life stages [27,31].

The findings of this study should be interpreted in light of its strengths and limitations. First, the large study sample of preschool children from six European countries and three socioeconomic strata, as well as the fact that immigrant participants were included in the study sample, comprise strengths of the study. Moreover, overweight/obesity was based on objective measures conducted by rigorously trained researchers who achieved excellent intra- and interobserver reliability and defined according to one common criterion applied for all countries [32], and the questionnaires (to record sociodemographic, perinatal, and behavioral data) had "moderate-to-excellent reliability" [33]. On the other hand, the cross-sectional design of the study prohibits from the identification of cause-effect associations. The fact that we did not control for gestational diabetes comprises another limitation. Furthermore, sociodemographic, perinatal, and behavioral data were self-reported and thus some socially desirable replies may be given, whereas perinatal data were collected retrospectively and most are based on self-reported parental recall. However, the large study sample may have counterbalanced these limitations. Data on maternal education were obtained only at the time of the preschool assessment, so any deviation from maternal education level in the perinatal period has not been reported. However, considering that the mean age of the mothers was 35.40 (4.8) y and that 61.9% of them reported to have at least two or more children, it seems unlikely that at least the majority of the mothers extended their education after their child's birth.

Conclusions

The present study has highlighted certain positive associations of preschooler's overweight/obesity with excess maternal prepregnancy and gestational weight gain, excess birth weight and rapid growth velocity, Southern and Eastern European region of residence, and parental overweight/obesity. Furthermore, it reported an interplay of perinatal factors, later childhood EBRBs, and low maternal education in relation to preschoolers' overweight/obesity. More specifically, maternal prepregnancy overweight/obesity, children's rapid growth velocity during infancy, and increased screen time were found to partially mediate the inverse association between maternal education and preschooler's BMI. These findings may support public health initiatives aiming to prevent early childhood obesity, because the most vulnerable parts of the society, and most specifically less-educated families, should be prioritized. Among other fields, these intervention initiatives should also focus on the importance of normal prepregnancy maternal weight status, normal growth velocity during infancy, and retaining screen time within recommendations.

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