

The impact of perinatal history in the occurrence of childhood obesity: a literature review

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Abstract

Background: It is widely accepted, that the increased prevalence of childhood overweight and obesity poses an important public health problem since it increases the risk for early onset of non-communicable diseases with potentially increased health complications during adulthood. Childhood obesity prevention is therefore of primary importance; hence it is mandatory to understand its main causes and identify the mechanisms associated with weight gain. Although its etiology can be partly attributed to genetic and behavioral factors, evidence from existing literature indicates that the perinatal environment may also increase the risk of childhood obesity; the latter, however, has not been thoroughly investigated and discussed.

Methods: A literature search was conducted in scientific databases (PubMed, Embase, Web of Science, and Scopus) in order to reveal recent epidemiologic studies, with emphasis on works from the last decade. Studies whose primary or secondary object was the association between type of delivery, breastfeeding and/or gestational diabetes mellitus with overweight and obesity in childhood and preadolescence were taken into account. Studies that did not meet the aim of the current review were excluded.

Results: The retrieved information revealed that there is a noteworthy association between perinatal factors and childhood and preadolescence overweight/obesity occurrence, though the exact pathways still need to be elucidated.

Conclusions: Public health professionals should take into account perinatal determinants when estimating a child's risk of overweight and obesity development. HIPPOKRATIA 2018, 22(4): 155-161.

Keywords: Perinatal history, type of delivery, breastfeeding duration, gestational diabetes mellitus, childhood overweight, childhood obesity

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Introduction

Childhood obesity is a worldwide public health burden, with global prevalence reaching 18 %, which is interpreted in 340 million children and adolescents aged 5-19 being affected in 2016¹. According to the existing literature, childhood obesity is a multifactorial condition, including genetic, behavioral, socioeconomic, and environmental factors^{2,3}. These factors, however, cannot explain in total the reasons for the childhood obesity epidemic. Other factors, specifically factors affecting the perinatal environment, have also been investigated and have been suggested to add to the etiology of childhood obesity, with three specific variables being thoroughly examined; type of birth (cesarean section or vaginal delivery)^{4,5}, duration of breastfeeding⁶⁻⁸, and presence of gestational diabetes mellitus^{9,10}.

The cesarean section appears to have an increasing worldwide trend in the recent decades; more specifically, a study in 2016, using nationally-representative data on

cesarean section rates from 150 countries, showed an absolute global increase of 12.4 % between 1990 and 2014¹¹. Additionally, a previous study in 137 countries noted that a high proportion of cesarean sections performed could be medically unnecessary¹². It has been argued that although the caesarian section is often necessary and unavoidable, the increased percentage in the past years, along with the increased childhood obesity rates during the same time period, raised questions of a potential association.

Concerning breastfeeding duration, the World Health Organization (WHO) recommends exclusive breastfeeding for the first six months and combination of breastfeeding and appropriate complementary foods until two years of age, for the infant's well-being¹³. However, only about 40 % of infants aged 0-6 months meet these recommendations, globally¹⁴. The observed decreased breastfeeding rates, along with the increased formula consumption and infant growth, might affect the child's risk of

overweight/obesity occurrence. Nevertheless, evidence remains controversial to date and need to be investigated and discussed.

Finally, gestational diabetes mellitus (GDM), defined as diabetes developed during pregnancy, is a known adverse risk factor for both the mother and the fetus. Concerning children's weight, according to the Centers for Disease Control and Prevention (CDC), GDM leads to a large for gestational age (LGA) infant¹⁵. It has been proposed that GDM is associated with greater body weight during infancy, and with continuous fat accumulation during childhood, leading to overweight and obesity. The evidence behind this hypothesis is conflicting as well, and studies investigating specifically GDM need to be discussed.

According to the aforementioned, the present work was a brief narrative review aiming to address existing data concerning the potential relationship between childhood overweight and obesity with specific perinatal risk factors; type of birth, breastfeeding duration, and exposure to gestational diabetes mellitus.

Methods

Literature search

A research was held retrieving original articles from scientific databases (PubMed, Embase, Web of Science, and Scopus), using the terms "perinatal environment", "type of delivery", "cesarean section" "C-section", "breastfeeding", "breastfeeding duration", "gestational diabetes", combined with "childhood overweight", "childhood obesity", "obesity in children", "increased Body Mass Index (BMI) in children" as keywords. Studies whose primary or secondary objective was the association of any of the three perinatal factors (type of birth, breastfeeding duration, and exposure to gestational diabetes mellitus) with childhood and preadolescence obesity (ages up to 18 years, with emphasis on ages 6-12 years) were included. The initial research provided 31 relevant published studies, of which six were discussing prospective cohorts, two case-control studies, nine cross-sectional studies, three retrospective studies, and 11 systematic reviews and/or meta-analyses (Figure 1).

The final review material included English written articles of the last decade (2008-2018), to account for research methodology differences observed during that period. Also, studies were selected based on the target population, with those investigating children less than 18 years of age being included. Papers were excluded if their full text was unavailable, exceeded the given time frame, examined small samples and/or diverged from the aim of the current review. The final set included 15 studies, of which five were prospective cohorts, one case-control study, five cross-sectional studies, two retrospective studies, and two systematic reviews and/or meta-analyses.

Delivery type and childhood obesity

Cesarean section delivery is progressively becoming a widespread surgical procedure since it may reduce the

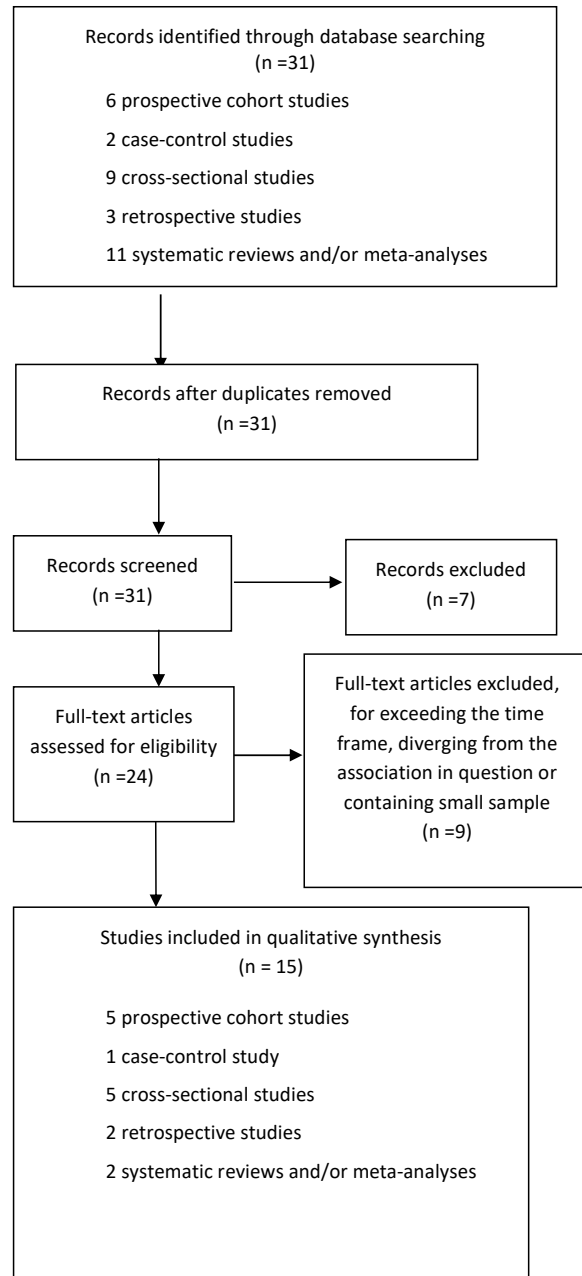


Figure 1: Flow chart of the conducted research, retrieving original articles from the scientific databases regarding the association between type of delivery, breastfeeding and/or gestational diabetes mellitus with overweight and obesity in childhood and preadolescence.

risk of morbidity to both mother and fetus, under specific situations as termed by their obstetrician¹⁶. However, it has also been regarded as a risk factor for childhood obesity^{17,18}. This association could be attributed to the fact that cesarean section leads to altered acquisition and structure of infants' gut microbiota in comparison with vaginal delivery^{19,20}, while recent research suggests that long-term effects of cesarean section on energy metabolism or appetite regulation may contribute to the signifi-

cant increase in body mass²¹.

A recent prospective cohort study found an effect between cesarean section and children's weight status. More specifically, the authors reported a 15 % greater chance of becoming obese in early childhood and pre-adolescence. It is also mentioned that among offsprings, whose mother's had undergone at least one previous cesarean section, the vaginally delivered infants were 31 % less likely to become obese later in life, compared to those born via cesarean delivery⁴. Results from a population-based study in a large sample of Chinese children were in accordance with those mentioned above, as the analysis showed that cesarean delivery increased the risk of developing early childhood overweight and obesity by 24 % and 29 % respectively⁵. Study results attributed the increased risk to the altered gut microbiota, although the mechanisms through which the association could be explained are not elucidated^{4,5}. In addition to the previous findings, a meta-analysis of seven cohort and two case-control studies revealed a 32 % higher risk of childhood overweight/obesity occurrence in 3-8 years of age¹⁷. Similarly, a more recent meta-analysis concluded that the risk of obesity in childhood and preadolescence (ages 2-15 years) was 34 % higher in children born via cesarean section. However, the heterogeneity of studies in the previous meta-analyses, combined with both potential residual confounding and publication bias, might affect the reliability of the results as mentioned above^{17,18}.

Regarding the age that children are more likely to be overweight or obese, the results remain ambiguous. In a

cohort study, it was stated that children born with cesarean section had double the risk of becoming overweight or obese at the age of six years compared to those born vaginally; while in the Lifestyle Immune System Allergy plus Air Pollution and Genetics (LISApplus) birth cohort study the most prevalent age was two years, though the researchers report a moderate follow-up dropout rate which could lead to selection bias^{6,22}. Additionally, a population-based survey suggested that birth via cesarean section was a predictor for obesity at six years of age⁸ (Table 1).

Breastfeeding duration and childhood obesity

Various mechanisms have been recommended to explain the association between breastfeeding duration and childhood obesity. Some studies have shown that satiety feelings could be recognized easier by infants, which could lead to the settlement of better self-regulation of energy intake later in life^{23,24}. Other researchers have reported that energy balance and food intake regulation is affected by breast milk hormones, and this could have an impact on body fat deposition²⁵. Another pathway through which breastfeeding could affect childhood bodyweight is by forming later food preferences. Specifically, it was documented that breastfed children adapt to new food more easily, possibly explained through the fact that the taste of breast milk varies with the mother's food choices²³. Also, the lower caloric intake and lower fat and protein levels provided by breast milk, in comparison with milk formula, could be another factor influ-

Table 1: Studies in the literature examining the associations between delivery type and childhood overweight/obesity occurrence.

Source	Study Sample	Type of Study	Location	Follow-up Period/Study Design	Study Results
Gopinath et al. 2012 ⁸	1,741 children aged 6 years and 2,354 children aged 12 years	Cross-sectional study (The Sydney Childhood Eye Study)	Sydney, Australia	Data collection about the perinatal environment retrospectively, through the use of questionnaires	Cesarean section was associated with obesity occurrence in the six-year-old cohort
Li et al. 2013 ¹⁷	7 cohort and 2 case control studies examining the association	Systematic review and meta-analysis	China, Brazil, United States of America, Denmark and Netherlands	Quantitative comparison in different age groups (children 3-8 years old, adolescents 9-18 years old and adults >19 years old)	Cesarean delivery was associated with 32% higher risk of childhood overweight/obesity occurrence (3-8 years of age)
Pei et al. 2014 ²²	3,097 healthy full-term neonates (gestational age >37 weeks and birth weight >2500 g)	Birth cohort study (LISApplus)	Munich, Leipzig, Wesel, and Bad Honnef, Germany	Follow-ups at 2, 6 and 10 years, including anthropometric measurements evaluation	Children born via cesarean section were at higher risk of developing obesity only at the age of two years
Kuhle et al. 2015 ¹⁸	4 case control, 19 cohort, and 5 cross sectional studies examining the association	Systematic review and meta-analysis	China, Brazil, United States of America, Denmark, Netherlands, Canada, Greece, Sri Lanka, Iran, Hong Kong, Poland and Germany	Quantitative comparison in children aged 2-15 years (mean age: 6 years)	Children born via cesarean section had 34 % higher risk of developing childhood obesity
Portela et al. 2015 ⁶	672 mother-baby pairs	Prospective cohort study	Feira de Santana, Brazil	Follow-up at 6 years	Cesarean section was a statistically significant factor for overweight/obesity occurrence at age 6 years

encing the prevalence of overweight and obesity among children^{26,27}.

A variety of studies have investigated the association between breastfeeding and childhood overweight and obesity, the past decade. A research team, based on data from the German Health Interview and Examination Survey for Children and Adolescents (KiGGS), a large cross-sectional study in Germany, reported that breastfeeding, either exclusive or combined with water and other fluids, for less than four months was a risk factor for obesity in both childhood and adolescence. Analysis stratified by age groups showed that being breastfed for four months or more was beneficial only in ages 7-10 years and had no statistical effect on fat accumulation in infancy, late childhood or adolescence⁷. These observations are in agreement with a previous analysis, carried out with data from the All Babies in Southeast Sweden (ABIS) prospective cohort study. Specifically, it was suggested that exclusive breastfeeding for less than four months had no statistical influence on weight development in early childhood, after adjustment for potential confounders²⁸. In comparison, data analyses from a large population-based survey in Australia showed that breastfeeding for

less than three months was a statistically significant factor for overweight occurrence at 12 years of age, though it was marginally non-significant at 6 years of age, although they emphasized on the fact that their primary subject was eye disease and not obesity, therefore there might be missing information about variables relevant to obesity⁸. However, data from a birth cohort study found that breastfeeding for less than twelve months was associated with a higher prevalence of overweight and obesity at six years of age, although they did not describe breastfeeding as a risk factor, but rather as a modifier in the relationship between delivery via cesarean section and childhood overweight/obesity⁶.

Finally, two other research studies examined the effect of exclusive and non-exclusive breastfeeding, setting the cutoff point for the duration at six months. They both concluded that duration under that cutoff point was associated with an increased prevalence of overweight and obesity in childhood^{29,30} (Table 2).

Gestational diabetes mellitus and childhood obesity

Regarding gestational diabetes, it is mentioned that overweight and obese pregnant women develop gesta-

Table 2: Studies in the literature examining the associations between breastfeeding duration and childhood overweight/obesity occurrence.

Source	Study Sample	Type of Study	Location	Follow-up Period/Study Design	Study Results
Huus et al. 2008 ²⁸	16,058 neonates → 7,356 children at five years of age	Prospective cohort study (All Babies in Southeast Sweden Study)	Southeast Sweden	Follow-ups via questionnaire at ages 1, 2.5, and 5 years of age	There was a weak association between exclusive breastfeeding for < 4 months and obesity at age 5 years, but after adjustment for confounding factors, the association was non-significant
Gopinath et al. 2012 ⁸	1,741 children aged 6 years and 2,354 children aged 12 years	Cross-sectional study (The Sydney Childhood Eye Study)	Sydney, Australia	Data collection about the perinatal environment retrospectively, through the use of questionnaires	Breastfeeding for < 3 months was a statistically significant factor overweight occurrence in twelve-year-old cohort, while it was marginally non-significant in the six-year-old cohort
Shi et al. 2013 ²⁹	968 full-term children aged 6-11 years	Population-based study (Canadian Health Measures Survey)	Canada	Data collection about the perinatal environment retrospectively, through the use of questionnaires and interviews	Exclusive breastfeeding for 6 months was inversely associated with the occurrence of obesity in childhood (6-11 years of age)
Grube et al. 2015 ⁷	13,163 children and adolescents aged 3-17 years	Cross-sectional study (KiGGS)	Germany	Analysis of retrospectively collected data about breastfeeding duration	Breastfeeding for <4 months was a statistically significant risk factor for the occurrence of overweight and obesity on the overall sample. When analysis was carried out for different age groups (3-6, 7-10, 11-13 and 14-17 years of age), breastfeeding for ≥ 4 months had a beneficial effect on the occurrence of overweight and obesity only in ages 7-10 years
Portela et al. 2015 ⁶	672 mother-baby pairs	Prospective cohort study	Feira de Santana, Brazil	Follow-up at 6 years	Breastfeeding duration < 12 months was associated with higher prevalence of overweight and obesity at six years of age
Wang et al. 2017 ³⁰	1,234 neonates	Prospective study	United States of America	Follow-ups at 2, 3, and 4.5 years and at grade 1, 3, and 6, including anthropometric measurements evaluation	Obesity prevalence was lower among children that were breastfed for ≥6 months, in comparison with breastfeeding duration <6 months or no breastfeeding at all

tional diabetes more frequently compared to women with normal weight³¹. It is speculated that intrauterine exposure to maternal GDM may increase the risk of childhood overweight and obesity development in exposed fetuses³²⁻³⁴.

An analysis from the multinational, cross-sectional International Study of Childhood Obesity, Lifestyle and the Environment (ISCOLE), reported that intrauterine exposure to GDM was a statistically significant risk factor for the development of central obesity in ages 9-11 years⁹. In a retrospective study, GDM was associated with childhood obesity, although it seemed to have a weaker effect on the overweight occurrence in children with mean age 5.8 years¹⁰. Additionally, a retrospective study performed on Chinese population showed that offspring of mothers with GDM had a higher prevalence of overweight and obesity in ages 5-10 years³⁵.

However, it was suggested that the mother's pregravid body mass index (BMI) influences the child's weight development rather than intrauterine exposure to GDM³⁶. In addition, there is evidence that overweight and obese pregnant women develop gestational diabetes more frequently compared to women with normal weight³¹. Therefore questions remain as to the actual effect of GDM on children's weight status later in life, with two of the above-mentioned studies agreeing that the association might be mediated by mother's pregravid BMI^{9,10}, and the third describing the relationship as "independent of maternal obesity"³⁵.

Additionally, a recent study in the Greek population proposed that mother's gestational weight gain could be the determining factor for obesity development in children, though GDM was not evaluated³⁷. Furthermore, a research team in Greece based on the cross-sectional "Healthy Growth Study" developed the Childhood Obesity Risk Evaluation (CORE) index, for the early detection of childhood obesity risk, using only mother's pregravid weight status to represent the effect of the perinatal environment, considering though that GDM might improve the index's accuracy³⁸ (Table 3).

Discussion

Bodyweight increase and fat accumulation in childhood is a multifactorial process. The perinatal environment seems to play an important role in a child's development and more specifically in the possibility of overweight and/or obesity occurrence. The present paper aimed to provide an integrated overview of the most recent state of knowledge regarding specific perinatal factors and childhood obesity hence contributing to future research. More specifically, this review explores the effect of the perinatal environment through the prism of three different factors: type of delivery, breastfeeding duration, and exposure to gestational diabetes mellitus. The present work was a brief narrative review; nevertheless, it results in some noteworthy observations. However, more studies on the independent effect of GDM on childhood

Table 3: Studies in the literature examining the associations between gestational diabetes mellitus and childhood overweight/obesity occurrence.

Source	Study Sample	Type of Study	Location	Follow-up Period Study Design	Study Results
Catalano et al. 2009 ³⁶	89 mother-offspring dyads	Prospective case-control study	United States of America	Follow up between 6 and 11 years of age of children, for body composition evaluation	Even though there existed a statistically significant difference on the BMI z-score in the exposed and unexposed to gestational diabetes mellitus children, the strongest predictor of childhood obesity seemed to be maternal pregravid BMI
Nehring et al. 2013 ¹⁰	7,355 mother-child dyads (mean age of children: 5.8 years)	Retrospective cohort study (Perinatal Prevention of Obesity)	Bavaria, Germany	Data collection about the perinatal environment retrospectively, through the use of questionnaires	A statistically significant association was found between maternal gestational diabetes mellitus and overweight and obesity in children
Zhao et al. 2015 ³⁵	2,833 term-born children aged 1-10 years and their mothers	Retrospective study	Yunnan province, China	Data collection about the perinatal environment retrospectively, through telephone interviews	Offsprings exposed to gestational diabetes mellitus had a higher prevalence of overweight and obesity in ages 5-10 years
Zhao et al. 2016 ⁹	4,740 children aged 9-11 years	Cross-sectional study (ISCOLE)	Australia, Brazil, Canada, China, Colombia, Finland, India, Kenya, Portugal, South Africa, the UK and the USA	Data collection about the perinatal environment retrospectively, through the use of questionnaires	Intrauterine exposure to gestational diabetes mellitus was a statistically significant risk factor for the development of central obesity in ages 9-11 years

BMI: Body Mass Index

obesity are necessary while accounting for maternal pre-gravid weight status.

Concerning the type of delivery, a considerable proportion of studies agreed that cesarean section was a risk factor for childhood overweight and obesity, with two systematic reviews further underlying the association^{17,18}. Delivery via cesarean section seemed to be the most important perinatal factor on the occurrence of childhood and preadolescence overweight/obesity. The differences in intrapartum bacterial exposure and, as a result, the altered gut microbiota acquisition have been shown to affect the way the human body functions, thus influencing food processing and fat accumulation³⁹⁻⁴¹. In addition to our results, previous studies have suggested that the increased risk also affects early childhood and adulthood as well^{42,43}. Although the cesarean section is a procedure that aims to protect mother and infant's lives and overall health, the conclusion that derives from this work's evidence was that it should be avoided in cases where it is not necessary, as it might have a burdening impact in many aspects of one's health.

Regarding breastfeeding, reviewed studies examined the effect of different durations, though they all concluded that the shorter the breastfeeding period, the greater the risk for obesity development, mostly in late childhood than in early or in adolescence. Our results agree with those of two previous meta-analyses; the first one investigated the association in 69,000 children and concluded that breastfeeding had a small though a significant protective effect against childhood obesity⁴⁴. The other meta-analysis examined the effect of different breastfeeding periods on body fat accumulation and showed that for each month of breastfeeding up to 9 months, the risk of overweight was decreased by 4 % in all ages⁴⁵. It is a known fact that breastfeeding plays a vital role in the existence of one's overall improved health^{13,46-48}; thus it should be highly recommended. Protection against childhood obesity could be one additional benefit of breastfeeding, independently of its duration; therefore, its early initiation is imposed.

As for maternal GDM, it seems that it might have a crucial role in the occurrence of overweight/obesity in children, although two studies indicated that the association could be mediated by maternal pre-pregnancy body weight⁹⁻¹⁰. A previous study has suggested that it is the mother's weight status, rather than maternal GDM, the determinant that affects neonate's body weight, and therefore neonate's adiposity level⁴⁹. A meta-analysis of 12 studies that investigated the association between GDM and childhood overweight/obesity reported no clear evidence, though they attributed the inconsistency in their results to methodological limitations and heterogeneity among the included studies⁵⁰. Regardless of the ambiguities, mother's healthy body weight could be a good predictive marker for the infant's health; therefore, it should be suggested to maintain or achieve it before impregnation.

Conclusions

To summarize, the perinatal environment plays an essential role in body development and weight accumulation in children. The present review reports studies of the latest era showing that type of delivery, breastfeeding duration, and exposure to gestational diabetes mellitus, are most likely important perinatal risk factors. These, therefore, need to be acquired during medical and nutritional history assessment and should be considered by public health professionals, in order to accurately evaluate a child's risk for overweight and/or obesity occurrence.

Conflict of interest

Authors declare no conflict of interest and no competing financial interest.

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