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Original Article

Exposure to low outdoor temperature in the midtrimester is associated with low birth weight

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Abstract

Background: Although seasonal variation of birth weight has been reported previously, contributing factors such as the meteorological factor and its specific period of exposure remain unclear.

Aim: To investigate the effect of season on birth weight and to determine the meteorological factor and its specific period of exposure which can contribute to any seasonal variation in birth weight.

Methods: Retrospective analysis of 3333 singleton live births after 36 completed weeks of pregnancy. Maternal age, parity, route of delivery, sex and individual meteorological variables for the first, second, and third trimesters of each pregnancy were analysed using multiple regression analysis with the birth weight as the dependent variable.

Results: A seasonal pattern was observed with lowest birth weights in women who had their last menstrual periods in summer and autumn. Upon multiple regression analysis, sex, parity, mode of delivery, and the temperature which the mother was exposed to in the second trimester were the independent determinants of birth weight.

Conclusion: Exposure to low outdoor ambient temperature in the midtrimester can be associated with low birth weight.

Key words: birth weight, humidity, meteorological factor, season, temperature.

Introduction

The fetal origins hypothesis states that stimuli or insults during critical or sensitive periods in early life can have lifetime consequences. Since McCance's studies in the 1960s on the long-term effects of early nutrition in rats, numerous animal studies have shown that nutrition in infancy or fetal life can induce lifetime effects on metabolism, growth, and neurodevelopment, and on major disease processes such as hypertension, diabetes, atherosclerosis, and obesity.[1–3] Studies in humans also have shown that small size at birth is associated with an increased propensity to adverse health outcomes in adulthood, including abnormal blood lipid values, diabetes, hypertension, and coronary heart disease.[1] These important primary observations have renewed the interest of investigators to identify factors affecting birth weight.

Seasonal variation of birth weight has been reported previously both in developed and developing countries.[4–8] However, there are also authors who have found no seasonal pattern.[9] Although seasonal variations in food availability and infections have been suggested as contributing factors to the seasonal variation in birth weight in underdeveloped countries, contributing factors in other countries remain unclear.[4,5]

In the present study, we aimed to investigate the effect of season on birth weight among deliveries in our university and, also, to determine the meteorological factor and its specific period of exposure which can contribute to any seasonal variation in birth weight.

Materials and methods

The present study is based on retrospectively compiled data from delivery records in Marmara University Hospital. Singleton live births after 36 completed weeks of pregnancy ($n = 3333$) between the years of 1992 and 2003 were included in the present study. All live births, except multiple pregnancies, were included in the study. Maternal age, parity, route of delivery, birth weight, sex, gestational week at delivery were analysed. Data were complete for these variables. Dates of women's last menstrual periods (LMP) were calculated for each birth by using duration of gestation and date of birth. Institutional review board approval was obtained from the Marmara University School of Medicine.

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Data on mean daily temperature (°C) and humidity (%), total daily rainfall (mm) and daily duration of daylight (hours) in the above-mentioned years were retrieved from the Turkish State Meteorological Service. Mean values for these data were calculated for the first, second, and third trimesters of each pregnancy.

Statistical analysis

The mean for birth weight was determined for each gestational week, and individual birth weights were expressed as multiples of the mean (MoM) for the relevant gestational week. Subjects were divided into four groups according to the season of the LMP (i.e. a woman with an LMP in January was included in the group of winter). Univariate comparisons between the four seasonal groups were made by using analysis of variance (ANOVA) and χ^2 tests, where appropriate.

To determine the individual meteorological variable, which is associated with seasonal variation, stepwise multiple regression analysis was performed by using the birth weight (MoM) as the dependent variable, and maternal age and parity, mode of delivery, sex, and temperature, humidity, rainfall and daylight values for each trimester as the independent variables. Values were expressed as mean ± SD, and a P-value of < 0.05 was considered significant. SPSS, Release 10.0 (SPSS, Inc, Chicago, IL, USA) was used for the statistical analysis.

Results

Maternal age, gestational week at delivery, Caesarean rate, rate of male infants and rate of nulliparous women were comparable between the four seasonal groups (Table 1). A clear seasonal pattern was observed with lowest birth weights in women, who had their LMPs in summer and autumn (Fig. 1a & Table 1).

The mean birth weight of males was higher than that of females ($P < 0.001$, Table 2). The mean birth weight for multiparous women was higher than that for nulliparous women ($P < 0.001$, Table 2). Older maternal age and Caesarean delivery were associated with higher birth weights ($P < 0.05$, Table 2). When stepwise multiple regression analysis was performed to determine the individual meteorological variable which is associated with the seasonal variation, sex, parity, mode of delivery, and the temperature which the mother was exposed in the second trimester were the independent determinants of birth weight (MoM) (Fig. 1, Table 3).

Discussion

In the present study, we observed a seasonal pattern in birth weight. Mothers who had their LMPs during summer and autumn had lighter infants than those who had their LMPs during winter and spring. Early work investigating seasonality and birth weight found that North American men born in the first 6 months of the year had a greater mean weight than those born in the second 6 months.[10] Many recent studies, but not all investigators, also have reported the effect of season on birth weight.[4–9]

Although food availability and infections can partly explain this seasonal variation in birth weight in underdeveloped countries, the contributing factors in developed countries remain unclear.[4,5] Recently, Murray et al. have analysed the

Table 1 Demographic data and meteorological variables to which women in the four seasonal groups were exposed

	Spring (n = 788)	Summer (n = 820)	Autumn (n = 981)	Winter (n = 744)	P
Age (years)	28.4 ± 5.0	28.7 ± 4.9	28.3 ± 4.8	28.3 ± 4.8	0.22
Gestational week at delivery	39.1 ± 1.2	39.1 ± 1.2	39.2 ± 1.2	39.2 ± 1.2	0.20
Nulliparous women (%)	54.3	53.5	53.7	54.0	0.37
Caesarean deliveries (%)	35.3	37.1	34.7	34.5	0.69
Males (%)	50.6	50.2	50.9	49.2	0.91
Birth weight (MoM)	1005 ± 0.117	0.994 ± 0.114	0.995 ± 0.116	1.008 ± 0.119	0.03
First trimester					
Temperature (°C)	18.5 ± 3.2	20.9 ± 2.4	10.7 ± 2.9	8.3 ± 2.2	< 0.001
Humidity	72.7 ± 1.3	75.4 ± 2.9	78.8 ± 2.6	75.7 ± 1.9	< 0.001
Rainfall (mm)	37.4 ± 12.4	38.4 ± 14.5	81.3 ± 20.1	64.9 ± 16.9	< 0.001
Daylight (hours)	14.5 ± 0.4	13.3 ± 1.0	10.5 ± 0.5	11.6 ± 1.0	< 0.001
Second trimester					
Temperature (°C)	21.1 ± 2.3	10.5 ± 2.9	8.3 ± 2.1	18.5 ± 3.4	< 0.001
Humidity	75.1 ± 2.8	78.2 ± 2.2	75.2 ± 1.9	72.8 ± 1.5	< 0.001
Rainfall (mm)	37.3 ± 14.8	75.0 ± 21.5	61.7 ± 18.3	37.0 ± 13.8	< 0.001
Daylight (hours)	13.4 ± 1.0	10.4 ± 0.4	11.6 ± 0.9	14.5 ± 0.5	< 0.001
Third trimester					
Temperature (°C)	10.5 ± 3.0	8.9 ± 2.3	18.6 ± 3.1	21.2 ± 2.5	< 0.001
Humidity	78.6 ± 2.6	74.5 ± 2.6	71.8 ± 2.5	75.3 ± 3.1	< 0.001
Rainfall (mm)	78.5 ± 18.6	59.5 ± 19.4	33.8 ± 11.3	37.5 ± 16.2	< 0.001
Daylight (hours)	10.4 ± 0.5	11.7 ± 1.0	14.5 ± 0.4	13.4 ± 1.0	< 0.001

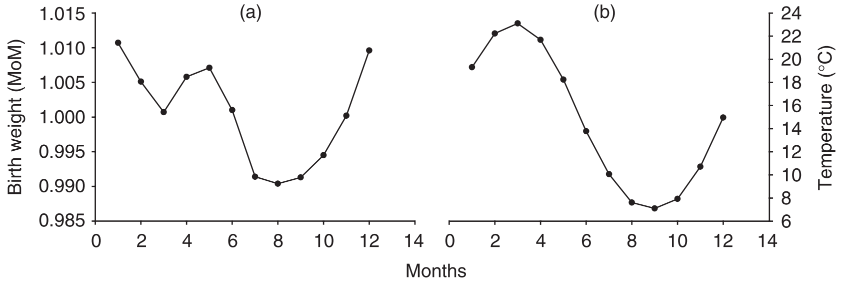

Figure 1 Seasonal variation of the birth weight (a) and environmental temperature (b).

Table 2 Comparison of birth weights between women who were grouped according to route of delivery, fetal sex, parity and age of women, using univariate analysis

	Birth weight (gr)	*P*	Birth weight (MoM)	*P*
Vaginal delivery	3367 ± 404		0.99 ± 0.11	
Caesarean delivery	3402 ± 429	0.02	1.01 ± 0.12	< 0.001
Female	3328 ± 394		0.98 ± 0.11	
Male	3430 ± 425	< 0.001	1.02 ± 0.12	< 0.001
Nulliparous women	3329 ± 394		0.99 ± 0.11	
Multiparous women	3437 ± 427	< 0.001	1.02 ± 0.12	< 0.001
Age ≤ 30	3365 ± 403		0.99 ± 0.11	
Age > 30	3410 ± 432	0.003	1.01 ± 0.12	< 0.001

Table 3 Stepwise multiple regression analysis for the determination of predictors of birth weight in MoM

	β (coefficient)	*t*-test value	*P*
Multiparous (1) versus nulliparous (0)	0.032	7.531	< 0.001
Male (1)† versus female (0)	0.030	7.090	< 0.001
Caesarean (1) versus vaginal (0) delivery	0.020	4.561	< 0.001
Temperature to which the subject was exposed during the second trimester (°C)	0.001	2.365	0.018

†Values in parenthesis indicate the value for the variable during the dummy coding.

contributing factors to this seasonal variation.[6] They have suggested that exposure to low temperature in the second trimester might directly result in low birth weight.[6] Upon analysis of different climacteric parameters during the three specific periods of gestation, we also found that outdoor temperature during the second trimester was the only independent parameter affecting the birth weight among the meteorological variables. In the present study, we observed that women who had their LMPs in winter and spring, were exposed to higher temperatures during the second trimester and delivered babies with higher birth weights than those who had their LMPs in summer and autumn.

The effect of heat stress on birth weight in non-human species has been addressed by several authors. Reduced birth weight following heat stress during pregnancy has been reported in mice, rats, guinea pigs, rabbits, goats, sheep, and cattle.[11] Growth retardation occurs in the presence of chronic, moderate heat stress.[11] However, the implications of these animal studies for humans must be considered with caution since the physiology of pregnancy varies by species, and the effect of environmental factors or fetal growth can vary likewise.

In humans, very few studies have focused on the effects of environmental temperature on birth weight.[6,12,13] In addition, most authors focused on adults. Heat stress is assumed to have played an important role in determining size and shape throughout hominid evolution. A negative correlation between adult mass and environmental temperature has been demonstrated by several authors, while variation in physique has also been attributed to thermal load.[14,15]

Seasonal variation in birth weight is not constant in every population.[4–9] The mechanisms can also be different between populations.[4,5] In addition, between-population variation in human size and shape is partly explained by the thermodynamic differences between populations.[12] Therefore, we should cautiously interpret the results in the present study and their application to other populations.

Humans, like other primates, have a relatively slow rate of fetal growth. However, although the daily incremental energy stress of pregnancy is lower than for any other mammal relative to body size, the fetus is potentially exposed to maternal thermal stress for a relatively long period.[16] Thus, the thermodynamics of pregnancy could play an important role in birth outcome.

Although we used the term 'exposure' in the present study, it should be mentioned that actual exposure to the environmental temperature might not be the mechanism. Instead, outdoor temperature can act as a proxy for some other factors such as exposure to infections and environmental smoke, food availability, physical activity, pregnancy-induced hypertension, hormonal and metabolic changes, all of which can vary by season.[17,18] Seasonal changes in hormonal systems, such as thyroid axis and glucose control, have previously been shown.[19–21] Glycosylated haemoglobin has been shown to be approximately 0.4% lower in the summer than in the winter, indicating that there is a relative worsening of insulin sensitivity in the winter.[22] To corroborate this, Behall *et al.* found that fasting insulin levels were over two-fold higher in the fall than in the spring.[21] This increased insulin resistance could cause an increase in birth weight. However, these findings contradict the results in the present study. We observed lighter babies in women who were exposed to lower temperatures during the second trimester, which is consistent with the results of Murray *et al.*[6] However, it should be mentioned that the above variations in metabolism have been suggested for non-pregnant subjects.

Increased growth hormone sensitivity could also explain the seasonal variation in birth weight. It has been suggested that the increased levels of IGF-I and IGFBP-3 is associated with higher outdoor temperatures.[23] This increase, in relation to season evaluated as outdoor temperature, without changes in GH, indicates that there is an increase in GH sensitivity during the warmer seasons.[23] It has been suggested that IGF-1 and IGFBP-3 was positively correlated with fetal body weight.[24,25]

The results in the present study are not consistent with the Bergman's law: 'In the same species, the body size of an animal increases along with latitude; that is, the lower the temperature, the larger the body size'.[13] Matsuda *et al.* also have reported that mean temperature correlated positively with mean birth weight.[13] This inconsistency is probably due to the many factors that affect the birth weight and complexity of the mechanisms.

There are limitations in the present study. Factors, which could have a seasonal pattern, and affect birth weight, that is, BMI, weight gain during pregnancy, pregnancy induced hypertension, diabetes, etc., could not be analysed. However, the aim of the study was to investigate the effect of season on birth weight and find the meteorological variable which might be associated with any seasonal pattern. The primary factor for the aetiology in the seasonal pattern of birth weight is expected to be the season or one of its meteorological parameters, or any other factor which changes secondary to season. Any possible secondary factor could not be analysed in the present study. Although there are several articles on the seasonal pattern of birth weight, to our knowledge, there is only one study that has tried to find the meteorological factor, which is independently associated with this seasonal pattern and specific period of exposure in pregnancy.[4–9]

In conclusion, exposure to low outdoor ambient temperature in the midtrimester can be associated with low birth weight. However, further studies should be performed to analyse the environmental factors affecting birth weight as well as the mechanisms of the relationships. This can help to decrease the perinatal morbidity and mortality associated with low birth weight.

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