Influence of Dietary Behaviors on Dyslipidemia in Pregnant Women and Its Effects on Physical Development of Fetuses and Infants: A Bidirectional Cohort Study

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Abstract: Background: Gestational diabetes can alter the trajectory of fetal development, but there are few studies on the effects of abnormal lipid metabolism on physical development of infants. We aimed to explore the prevalence of maternal dyslipidemia, its influencing factors and effects on the physical development of fetuses and infants, as well as the role of leptin in this process.

Methods: Questionnaire surveys and main outcome measures were administered among 338 pairs of pregnant women and newborns. Results: The detection rate of maternal dyslipidemia was 31.5%. The median levels of TG (triglyceride) and TG/HDL (high-density lipoprotein) ratio were higher in large-for-gestational-age (LGA) newborns. Birth weight was positively related to infants’ height and weight at six months and one year old ($p < 0.05$). Leptin was positively related to TG levels of pregnant women and newborns’ birth weight ($p < 0.05$). Logistic regression analysis showed that having greater than or equal to four meals a day (OR = 6.552, 95%CI = 1.014–42.338) and liking to eat lightly flavored food during pregnancy (OR = 1.887, 95%CI = 1.048–3.395) were independent risk factors of maternal dyslipidemia. Conclusions: The prevalence of dyslipidemia was relatively high in pregnant women and was affected by dietary behaviors. Abnormal lipid levels during pregnancy could affect weight and length at birth, which might be associated with increasing leptin levels in cord blood, and then the weight of infants would be influenced by birth weight.

Keywords: dyslipidemia; dietary; physical development; leptin; pregnancy

1. Introduction
The prevalence of obesity in children and adolescents has increased substantially around the world [1]. The causes of childhood obesity are complex. High birth weight has been shown to be a risk for childhood obesity, which is influenced by the early intrauterine environment. The Developmental Origins of Health and Disease (DOHaD) hypothesis suggests that nutrient excess in utero results in an acquired susceptibility to metabolic disease later in life and the early intrauterine environment is closely related to the metabolism of pregnant women [2]. At present, there are more reports about the effect of gestational diabetes on the physical development of fetuses. However, there are fewer studies that have focused on abnormal lipid metabolism of pregnant women, and its effect on physical development of fetuses. It is of great practical significance to study the relationship between lipid metabolism of pregnant women and the physical development of fetuses and infants, because of the higher prevalence of dyslipidemia in adulthood in...
China now. The metabolic pathways underlying early developmental programming in human infants at risk for obesity remain poorly understand. Studies indicate that leptin could affect glucose and lipid metabolism by direct or indirect approaches, through central mechanisms and via metabolically active hormones, such as insulin [3–5]. The aim of this study was to explore the effect of blood lipid levels of pregnant women on leptin levels in cord blood, and physical development of fetuses and infants.

The changes in diet and exercise behavior, and the occurrence of complex physiological phenomena during pregnancy, will affect the levels of maternal blood lipid, including total cholesterol (TC), triglyceride, low-density lipoprotein (LDL) and high-density lipoprotein cholesterol. Elevation of blood lipid levels due to pregnancy to a certain extent is physiological [6]. Nevertheless, when the blood lipid levels surpass the physiological range and develop into dyslipidemia (DLP), adverse pregnancy outcomes such as preeclampsia, prolonged pregnancy, preterm birth and macrosomia will occur [7–9]. Current researches’ conclusions about the influencing factors of maternal dyslipidemia are not consistent, so further study is needed to settle targeted preventive measures in the future to reduce the occurrence of maternal dyslipidemia and the incidence of adverse pregnancy outcomes.

The objective of the present study was to explore the influencing factors of women’s dyslipidemia during late gestation and its effects on the physical development of fetuses and infants, as well as the role of leptin in this process, in order to prevent maternal dyslipidemia and ensure the healthy growth and development of infants and young children.

2. Materials and Methods

2.1. Research Objects

A population-based bidirectional cohort study of 338 pairs of pregnant women and newborns was performed between January 2020 and July 2021. The participants in this study were recruited from a third-class A hospital by convenient sampling in Shenyang, China. This study was approved by the Medical Ethics Committee of the Fourth Affiliated Hospital of China Medical University and all participants had provided written informed consent (Reference number: EC-2019-KS-027).

Subjects were included in the study if: (1) they were aged \( \geq 18 \) years old; (2) they were natural singleton conception; (3) the newborns were live birth. Subjects were excluded from the study if: (1) they were multiple pregnancy; (2) the newborns were birth defects and stillbirth; (3) they suffered from acute and chronic infectious diseases, tumors, cardiovascular diseases or diabetes before pregnancy; (4) they had mental and intellectual disabilities.

2.2. Research Methods

The basic information of pregnant women including general demographic characteristics, dietary frequency, dietary habits, exercise and sleep conditions was gathered by the trained pediatricians through face-to-face surveys using questionnaires, while the standard height and weight measuring instrument was used to measure the height and weight of pregnant women by professionals. Calculated body mass index (BMI) was based on these parameters: \( \text{BMI} = \frac{\text{weight (Kg)}}{\text{height}^2 \text{ (m)}} \).

Diet-related information included the following aspects: (1) Main food intake frequencies included grains, meats, milk products, soy products, seafoods, vegetables, fruits, etc. (2) Snack intake frequencies included canned food, fried food, nuts, sweets, puffed food, beverages, etc. (3) Eating habits included breakfast, often to eat food before going to bed, whether to eat on time, meals per day, taste, types of drinking water, etc. Definition of snack intake frequencies was as follows: 4–5 times per week was regularly, 2–3 times per week was occasionally, and \( \leq 1 \) time per week was barely.

Fasting serum lipids: We informed pregnant women to fast for 12 h before getting up in the morning for blood sampling. TC, TG, HDL and LDL levels were detected by a fully automated biochemical analyzer (Siemens ADVIA2400). The abnormal lipid levels were
evaluated by the Williams Obstetrics when TC, TG and LDL were, respectively, higher than 7.73 mmol/L, 4.31 mmol/L and 4.76 mmol/L, and HDL was lower than 1.34 mmol/L [10]. Pregnant women were diagnosed with dyslipidemia if any one of the above four blood lipids was abnormal. Pregnant women with dyslipidemia were divided into the case group, and the others were divided into the control group.

The birth weight (kg) and birth length (cm) of newborns were gathered from delivery records, and then the height (cm) and weight (kg) of infants at six months and one year old were followed up by the trained pediatricians. We divided newborns into large-for-gestational-age and appropriate for gestational age according to the growth reference standards of newborns’ birth weight of different gestational ages in China. Large-for-gestational-age infants were identified when birth weight was >90th percentile standardized birth weight [11].

Cord blood samples obtained from umbilical veins were processed within one hour after birth. Serum was separated by centrifugation and stored at −80 °C until assayed. Leptin in 57 random neonatal cord blood samples was detected by ELISA kit (R&D Systems, Inc., Shanghai, China).

2.3. Statistical Analysis

Data management and analysis were performed using SPSS 22.0. Categorical variables were expressed as n (%), chi-squared test or fisher exact test was used to compare differences between groups. Normality tests for continuous variables were conducted. Non-normality variables were expressed as median (quartiles), and the Mann–Whitney U test was used to compare differences between groups. Correlation between two continuous variables was tested by Partial correlation. The logistic regression analysis was used to assess the risk factors of maternal dyslipidemia. The significance level of the p value was set at 0.05.

3. Results

A total of 338 pairs of pregnant women and infants participated in this study. The age (29.31 ± 3.99 years old), height (162.30 ± 5.33 cm), weight before pregnancy (58.31 ± 9.99 kg) and antenatal weight (74.75 ± 10.54 kg) of pregnant women, the birth weight (3.38 ± 0.41 kg) and birth length (50.58 ± 1.57 cm) of newborns, the weight (8.75 ± 1.07 kg) and height (69.34 ± 2.77 cm) of infants at six months, and the weight (10.36 ± 1.15 kg) and height (77.10 ± 2.70 cm) of infants at one year old are shown in Table 1.

Table 1. The basic information of pregnant women and the height and weight of newborns and infants.

| Items                | N  | M ± SD/% |
|----------------------|----|----------|
| Pregnant women       |    |          |
| Age (y)              | 338| 29.31 ± 3.99 |
| Height (cm)          | 338| 162.30 ± 5.33 |
| Weight before pregnancy (kg) | 338| 58.31 ± 9.99 |
| Antenatal weight (kg) | 338| 74.75 ± 10.54 |
| Newborns             |    |          |
| Birth weight (kg)    | 329| 3.38 ± 0.41  |
| Birth length (cm)    | 329| 50.58 ± 1.57 |
| Six months           |    |          |
| Weight (kg)          | 315| 8.75 ± 1.07  |
| Height (cm)          | 315| 69.34 ± 2.77 |
| One year old         |    |          |
| Weight (kg)          | 280| 10.36 ± 1.15 |
| Height (cm)          | 280| 77.10 ± 2.70 |

Note: Some of the variables had missing values.

According to the Williams Obstetrics, the overall abnormal rates of TC, TG, HDL-c, LDL-c of pregnant women were 7.1%, 23.4%, 1.7%, 6.4%. The prevalence of dyslipidemia
was 31.5% under the standards that one of the above was abnormal. Meanwhile, the prevalence rate of maternal dyslipidemia was 5.2% as per self-report, far lower than 31.5% \((p < 0.001)\), as shown in Table 2.

**Table 2.** The detection rates of abnormal blood lipids of pregnant women.

| Items                  | N    | Abnormal | Detection Rate |
|------------------------|------|----------|----------------|
| TC (mmol/L)            | 295  | 21       | 7.1%           |
| TG (mmol/L)            | 295  | 69       | 23.4%          |
| HDL-c (mmol/L)         | 295  | 5        | 1.7%           |
| LDL-c (mmol/L)         | 295  | 19       | 6.4%           |
| One of the above was   | 295  | 93       | 31.5%          |
| abnormal               |      |          |                |
| Self-report            | 291  | 15       | 5.2%           |

Note: Some of the variables had missing values.

The median levels of TG and TG/HDL ratio were higher in LGA newborns; infants’ height and weight at six months and one year old were higher in LGA newborns than in appropriate for gestational age newborns, shown in Table 3.

**Table 3.** Comparison of blood lipid levels of pregnant women and the weight and height of infants in LGA and appropriate for gestational age groups (median, quartiles).

| Items                  | LGA \((n = 71)\) | Appropriate for Gestational Age \((n = 230)\) | Test Value | \(p\) Value |
|------------------------|------------------|---------------------------------------------|------------|-------------|
| TC (mmol/L)            | 6.04(5.39, 7.01)| 6.01(5.35, 6.86)                          | 0.166      | 0.868       |
| TG (mmol/L)            | 3.90(2.94, 4.68)| 3.26(2.69, 4.07)                          | 2.668      | 0.008       |
| HDL (mmol/L)           | 1.87(1.66, 2.11)| 1.90(1.65, 2.24)                          | 0.587      | 0.558       |
| LDL (mmol/L)           | 3.07(2.42, 3.72)| 3.13(2.52, 3.95)                          | 0.933      | 0.351       |
| TC/HDL                 | 3.19(2.79, 3.57)| 3.07(2.77, 3.59)                          | 0.493      | 0.622       |
| TG/HDL                 | 2.08(1.59, 2.68)| 1.74(1.35, 2.20)                          | 2.746      | 0.006       |
| LDL/HDL                | 1.65(1.23, 1.94)| 1.62(1.33, 2.05)                          | 0.686      | 0.493       |
| Weight (six months, kg)| 9.00(8.50, 9.60)| 8.50(8.00, 9.50)                          | 2.973      | 0.003       |
| Height (six months, cm)| 70.00(69.00, 72.00)| 69.00(67.50, 70.50)            | 3.743      | <0.001      |
| Weight (one year old, kg)| 10.50(10.00, 11.50)| 10.00(9.50, 11.00)         | 3.128      | 0.002       |
| Height (one year old, cm)| 78.50(76.00, 80.00)| 76.50(75.00, 78.50)       | 3.739      | <0.001      |

The HDL levels were negatively related to the weight and height of infants at six months in the case of controlling birth weight and birth length \((r_s = -0.157, p = 0.017; r_s = -0.144, p = 0.029, \) respectively), while other blood lipid levels had nothing to do with the weight and height of infants in the case of controlling birth weight and birth length \((p > 0.05)\). Birth weight was positively related to infants’ height and weight at six months and one year old \((r_s = 0.322, p < 0.001; r_s = 0.344, p < 0.001; r_s = 290, p < 0.001; r_s = 0.316, p < 0.001, \) respectively), shown in Table 4.
Table 4. Correlation between blood lipid levels of pregnant women, birth weight and the height and weight of infants.

| Items                  | Weight (Six Months, kg) | Height (Six Months, cm) | Weight (One Year Old, kg) | Height (One Year Old, cm) |
|------------------------|-------------------------|-------------------------|---------------------------|---------------------------|
| TC (mmol/L)            | rs (n = 229) 0.003      | rs (n = 229) 0.008      | rs (n = 229) −0.015       | rs (n = 229) −0.025       |
| p value                | 0.966                   | 0.901                   | 0.815                     | 0.701                     |
| TG (mmol/L)            | rs (n = 229) 0.073      | rs (n = 229) 0.014      | rs (n = 229) 0.018        | rs (n = 229) 0.001        |
| p value                | 0.272                   | 0.835                   | 0.780                     | 0.990                     |
| HDL (mmol/L)           | rs (n = 229) −0.157     | rs (n = 229) −0.144     | rs (n = 229) −0.053       | rs (n = 229) −0.023       |
| p value                | 0.017                   | 0.029                   | 0.421                     | 0.733                     |
| LDL (mmol/L)           | rs (n = 229) 0.013      | rs (n = 229) 0.038      | rs (n = 229) 0.006        | rs (n = 229) 0.005        |
| p value                | 0.845                   | 0.571                   | 0.926                     | 0.942                     |
| TC/HDL                 | rs (n = 229) 0.100      | rs (n = 229) 0.102      | rs (n = 229) 0.017        | rs (n = 229) −0.005       |
| p value                | 0.131                   | 0.123                   | 0.799                     | 0.937                     |
| TG/HDL                 | rs (n = 229) 0.077      | rs (n = 229) 0.025      | rs (n = 229) 0.010        | rs (n = 229) −0.004       |
| p value                | 0.247                   | 0.704                   | 0.884                     | 0.957                     |
| LDL/HDL                | rs (n = 229) 0.092      | rs (n = 229) 0.124      | rs (n = 229) 0.041        | rs (n = 229) 0.031        |
| p value                | 0.162                   | 0.061                   | 0.537                     | 0.644                     |
| Birth weight (kg)      | rs (n = 229) 0.322      | rs (n = 229) 0.344      | rs (n = 229) 0.290        | rs (n = 229) 0.316        |
| p value(n = 251)       | <0.001                  | <0.001                  | <0.001                    | <0.001                    |

There was a positive correlation between leptin in cord blood and TG levels of pregnant women in the third trimester of pregnancy ($p = 0.025$), shown in Figure 1, while the leptin had nothing to do with TC levels, HDL-c levels, LDL-c levels or the TC/HDL ratio, TG/HDL ratio, or LDL/HDL ratio ($p > 0.05$, not shown in figures below).

![Figure 1](image-url)  
**Figure 1.** Correlation between leptin in cord blood and TG levels of pregnant women.

Leptin in cord blood was positively related to newborns’ birth weight ($p < 0.001$), shown in Figure 2, but was not directly related to infants’ weight at six months and one year old ($p > 0.05$, not shown in figures below).
Figure 2. Correlation between leptin in cord blood and the birth weight.

Compared with the control group, the proportion of pregnant women whose age was higher than 30 years old, family financial status was well, or weight gain was excessive during pregnancy was higher in the case group (44.1% vs. 38.1%; 10.8% vs. 5.4%; 38.7% vs. 33.2%, respectively), and the proportion of passive smoking before or after pregnancy was lower in the case group (41.9% vs. 46.0%; 28.0% vs. 32.7%, respectively). None of the differences above were statistically significant (p > 0.05). There was no significant difference in the proportion of pregnant women with family history of diabetes or hypertension between the control group and the case group (p > 0.05), shown in Table 5.

| Items                          | Control Group (n = 202) | Case Group (n = 93) | Test Value | p Value |
|-------------------------------|-------------------------|---------------------|------------|---------|
| Age                           | ≤24                     | 13(6.4)             | 8(8.6)     | 2.388   | 0.496   |
|                               | 25–29                   | 109(54.0)           | 43(46.2)   |          |         |
|                               | 30–35                   | 59(29.2)            | 34(36.6)   |          |         |
|                               | >35                     | 18(8.9)             | 7(7.5)     |          |         |
| Education                     | high school or below    | 44(21.8)            | 25(26.9)   | 0.820   | 0.664   |
|                               | Undergraduate           | 140(69.3)           | 61(65.6)   |          |         |
|                               | Master degree or above  | 13(6.4)             | 6(6.5)     |          |         |
| Family monthly income (yuan)  | ≤3000                   | 178(88.1)           | 83(89.2)   | 0.570   | 0.450   |
|                               | >3000                   | 12(5.9)             | 8(8.6)     |          |         |
| Family financial status       | Well                    | 11(5.4)             | 10(10.8)   | 2.662   | 0.264   |
|                               | Normal                  | 156(77.2)           | 69(74.2)   |          |         |
|                               | Bad                     | 31(15.3)            | 13(14.0)   |          |         |
|                               | Thin                    | 33(16.3)            | 14(15.1)   | 0.708   | 0.871   |
|                               | Normal weight           | 117(57.9)           | 54(58.1)   |          |         |
|                               | Overweight              | 34(16.8)            | 16(17.2)   |          |         |
|                               | Obesity                 | 12(5.9)             | 8(8.6)     |          |         |
| Weight gain(kg)               | Insufficient            | 50(24.8)            | 19(20.4)   | 1.045   | 0.393   |
|                               | Suitable                | 79(39.1)            | 37(39.8)   |          |         |
|                               | Excessive               | 67(33.2)            | 36(38.7)   |          |         |
| Passive smoking before pregnancy | Yes                  | 93(46.0)            | 39(41.9)   | 0.425   | 0.514   |
|                               | No                      | 105(52.0)           | 52(55.9)   |          |         |
| Passive smoking after pregnancy | Yes                  | 66(32.7)            | 26(28.0)   | 0.788   | 0.375   |
|                               | No                      | 127(62.9)           | 64(68.8)   |          |         |
| Family history of diabetes    | Yes                     | 25(12.4)            | 14(15.1)   | 0.340   | 0.560   |
|                               | No                      | 174(86.1)           | 79(84.9)   |          |         |
| Family history of hypertension | Yes                    | 26(12.9)            | 15(16.1)   | 0.470   | 0.493   |
|                               | No                      | 172(85.1)           | 78(83.9)   |          |         |
| Mood during pregnancy         | Well                    | 78(38.6)            | 32(34.4)   | 0.417   | 0.812   |
|                               | Better                  | 92(45.5)            | 45(48.4)   |          |         |
|                               | Normal                  | 30(14.9)            | 13(14.0)   |          |         |

Note: Some of the variables had missing values.
Compared with the control group, the intake frequencies of common food, such as coarse grain, vegetables, fruits, soy products, and milk products, greater than or equal to 1 time/day for pregnant women during pregnancy were a bit higher, while the intake frequencies of lean meat and eggs greater than or equal to 1 time/day and of seafoods and liver greater than or equal to 4 times/week were a bit lower in the case group. None of the differences above were statistically significant ($p > 0.05$), as shown in Table 6.

### Table 6. Comparison of the common food intake frequencies of women during pregnancy between the control and case groups ($n$, %).

| Items                  | Control Group ($n = 202$) | Case Group ($n = 93$) | Test Value | $p$ Value |
|------------------------|---------------------------|-----------------------|------------|-----------|
| **Staple food**        |                           |                       |            |           |
| (rice/steamed bun/noodles, etc.) | ≥1 time/day | 159(78.7) | 73(78.5) | 0.020 | 0.887 |
|                        | <1 time/day               | 41(20.3) | 18(19.4) |           |           |
| **Coarse grain**       |                           |                       |            |           |
|                        | ≥1 time/day               | 25(12.4) | 15(16.1) | 0.749 | 0.387 |
|                        | <1 time/day               | 172(85.1) | 76(81.7) |           |           |
| **Vegetables**         |                           |                       |            |           |
|                        | ≥1 time/day               | 166(82.2) | 81(87.1) | 0.523 | 0.469 |
|                        | <1 time/day               | 32(16.3) | 12(12.9) |           |           |
| **Fruits**             |                           |                       |            |           |
|                        | ≥1 time/day               | 173(85.6) | 84(90.3) | 0.393 | 0.531 |
|                        | <1 time/day               | 24(11.9) | 9(9.7) |           |           |
| **Lean meat**          |                           |                       |            |           |
| (livestock, poultry)   | ≥1 time/day               | 91(45.0) | 40(43.0) | 0.189 | 0.664 |
|                        | <1 time/day               | 108(53.5) | 53(57.0) |           |           |
| **Eggs**               |                           |                       |            |           |
|                        | ≥1 time/day               | 102(50.5) | 42(45.2) | 1.022 | 0.312 |
|                        | <1 time/day               | 96(47.5) | 51(54.8) |           |           |
| **Soy products**       |                           |                       |            |           |
|                        | ≥1 time/day               | 30(14.9) | 15(16.1) | 0.074 | 0.785 |
|                        | <1 time/day               | 167(82.7) | 76(81.7) |           |           |
| **Milk products**      |                           |                       |            |           |
|                        | ≥1 time/day               | 102(50.5) | 51(54.8) | 0.513 | 0.474 |
|                        | <1 time/day               | 96(47.5) | 40(43.0) |           |           |
| **Seafoods**           |                           |                       |            |           |
|                        | ≤1 time/week              | 136(67.3) | 68(73.1) | 0.748 | 0.688 |
|                        | 2–3 times/week            | 42(20.8) | 17(18.3) |           |           |
|                        | ≥4 times/week             | 19(9.4) | 7(7.5) |           |           |
| **Liver**              |                           |                       |            |           |
|                        | ≤1 time/week              | 161(79.7) | 81(87.1) | 1.570 | 0.456 |
|                        | 2–3 times/week            | 24(11.9) | 9(9.7) |           |           |
|                        | ≥4 times/week             | 12(5.9) | 3(3.2) |           |           |

Note: Some of the variables had missing values.

The ‘barely intake’ frequencies of canned food, barbecue, fried food, puffed food, beverages and coffee of pregnant women during pregnancy between the control and case groups were quite unanimous; all of them were higher than 85% ($p > 0.05$). The ‘barely intake’ frequencies of sweets and the ‘occasionally or regularly intake’ frequencies of nuts were around 60% in both control and case groups ($p > 0.05$). The ‘regularly intake’ frequencies of health products and the proportion of vitamin D supplement were between 71% and 81% in both control and case groups ($p > 0.05$), as shown in Table 7.

Compared with the control group, the proportion of pregnant women who had equal to or more than three meals a day or who liked to eat lightly flavored food during pregnancy was higher in the case group (46.3% vs. 28.2%; 78.5% vs. 65.8%, $p < 0.05$). There were no statistically significant differences in eating habits including breakfast, often eating food before going to bed, eating on time, other tastes, and types of drinking water between the control and case groups, as shown in Table 8.
Table 7. Comparison of the snack intake frequencies of women during pregnancy between the control and case groups (n, %).

| Items                                      | Control Group (n = 202) | Case Group (n = 93) | Test Value | p Value |
|--------------------------------------------|-------------------------|---------------------|------------|---------|
| Sausages and cooked meat products          |                         |                      |            |         |
| barely                                     | 158(78.2)               | 70(75.3)            | 0.689      | 0.708   |
| occasionally                               | 31(15.3)                | 18(19.4)            |            |         |
| regularly                                  | 8(4.0)                  | 4(4.3)              |            |         |
| Canned food (pork, beef, fish, mutton, etc.)|                         |                      |            |         |
| barely                                     | 196(97.0)               | 91(97.8)            | *          | 0.554   |
| occasionally                               | 3(1.5)                  | 0(0.0)              |            |         |
| regularly                                  | 1(0.5)                  | 0(0.0)              |            |         |
| Barbecue                                   |                         |                      |            |         |
| barely                                     | 188(93.1)               | 86(92.5)            | 0.231 *    | 1.000   |
| occasionally                               | 8(4.0)                  | 4(4.3)              |            |         |
| regularly                                  | 4(2.0)                  | 2(2.2)              |            |         |
| Nuts (walnuts, peanuts, melon seeds, etc.) |                         |                      |            |         |
| barely                                     | 77(38.1)                | 39(41.9)            | 0.757      | 0.685   |
| occasionally                               | 50(24.8)                | 19(20.4)            |            |         |
| regularly                                  | 72(35.6)                | 34(36.6)            |            |         |
| Fried food                                 |                         |                      |            |         |
| barely                                     | 182(90.1)               | 82(88.2)            | 1.327      | 0.515   |
| occasionally                               | 12(5.9)                 | 5(5.4)              |            |         |
| regularly                                  | 4(2.0)                  | 4(4.3)              |            |         |
| Sweets (ice cream, candies, biscuits, pastries, etc.) |            |                      |            |         |
| barely                                     | 173(85.6)               | 85(91.4)            | 3.202      | 0.202   |
| occasionally                               | 15(7.4)                 | 5(5.4)              |            |         |
| regularly                                  | 10(5.0)                 | 1(1.1)              |            |         |
| Beverages (juice, cola, sprite, etc.)      |                         |                      |            |         |
| barely                                     | 194(96.0)               | 91(97.8)            | 0.994 *    | 1.000   |
| occasionally                               | 1(0.5)                  | 0(0.0)              |            |         |
| regularly                                  | 2(1.0)                  | 0(0.0)              |            |         |
| Coffee                                     |                         |                      |            |         |
| barely                                     | 36(17.8)                | 14(15.1)            | 1.902      | 0.386   |
| occasionally                               | 15(7.4)                 | 4(4.3)              |            |         |
| regularly                                  | 144(71.3)               | 75(80.6)            |            |         |
| Health products (calcium, zinc, iron, vitamins, etc.) |            |                      |            |         |
| barely                                     | 133(65.8)               | 73(78.5)            | 4.839      | 0.028   |
| occasionally                               | 69(34.2)                | 20(21.5)            |            |         |
| regularly                                  | 63(3.0)                 | 10(10.8)            |            |         |
| Vitamin D supplement                       |                         |                      |            |         |
| Yes                                        | 158(78.2)               | 66(71.0)            | 2.082      | 0.149   |
| No                                         | 41(20.3)                | 26(28.0)            |            |         |

Note: Some of the variables had missing values; * Fisher exact test was used.

Table 8. Comparison of the eating and drinking habits of women during pregnancy between the control and case groups (n, %).

| Items                                      | Control Group (n = 202) | Case Group (n = 93) | Test Value | p Value |
|--------------------------------------------|-------------------------|---------------------|------------|---------|
| Breakfast regularly                        | 185(91.6)               | 81(87.1)            | 0.708      | 0.400   |
| occasionally                               | 16(7.9)                 | 10(10.8)            |            |         |
| Often to eat food before going to bed      |                         |                      |            |         |
| Yes                                        | 72(35.6)                | 34(36.6)            | 0.023      | 0.879   |
| No                                         | 130(64.4)               | 59(63.4)            |            |         |
| whether to eat on time                     |                         |                      |            |         |
| Yes                                        | 175(86.6)               | 80(86.0)            | 0.020      | 0.887   |
| No                                         | 27(13.4)                | 13(14.0)            |            |         |
| Meals per day                              |                         |                      |            |         |
| 1 time                                     | 8(4.0)                  | 2(2.2)              | 12.738     | 0.005   |
| 2 times                                    | 137(67.8)               | 48(51.6)            |            |         |
| 3 times                                    | 51(25.2)                | 33(35.5)            |            |         |
| ≥4 times                                   | 6(3.0)                  | 10(10.8)            |            |         |
| Like to eat lightly flavored food          |                         |                      |            |         |
| Yes                                        | 133(65.8)               | 73(78.5)            | 4.839      | 0.028   |
| No                                         | 69(34.2)                | 20(21.5)            |            |         |
| Like to eat fried food                     |                         |                      |            |         |
| Yes                                        | 24(11.9)                | 10(10.8)            | 0.080      | 0.778   |
| No                                         | 178(88.1)               | 83(89.2)            |            |         |
| Like to eat salty food                     |                         |                      |            |         |
| Yes                                        | 35(17.3)                | 19(20.4)            | 0.410      | 0.522   |
| No                                         | 167(82.7)               | 74(79.6)            |            |         |
Table 8. Cont.

| Items                              | Control Group      | Case Group        | Test Value | p Value |
|------------------------------------|--------------------|-------------------|------------|---------|
| Like to eat sour food              | Yes: 50(24.8)      | No: 152(75.2)     | 0.000      | 0.997   |
| Like to eat sweet food             | Yes: 67(33.2)      | No: 135(66.8)     | 0.216      | 0.642   |
| Like to eat spicy food             | Yes: 53(26.2)      | No: 148(73.3)     | 3.587      | 0.058   |
| Drink boiled water regularly       | Yes: 161(79.7)     | No: 41(20.3)      | 0.057      | 0.812   |
| Drink juice regularly              | Yes: 7(3.5)        | No: 195(96.5)     | *          | 0.527   |
| Drink sweet drinks regularly       | Yes: 10(5.0)       | No: 201(99.5)     | *          | 0.094   |
| Drink carbonated beverages regularly | Yes: 3(1.5)      | No: 199(98.5)     | *          | 1.000   |
| Drink plastic barreled water regularly | Yes: 33(16.3)  | No: 169(83.7)     | 0.735      | 0.391   |
| Drink plastic bottled water regularly | Yes: 25(12.4) | No: 177(87.6)     | 0.161      | 0.689   |

Note: Some of the variables had missing values; * Fisher exact test was used.

Compared with the control group, the proportion of pregnant women who had an elevator at home, watched TV more than 2 h per day, and played mobile more than 3 h per day were higher in the case group. None of the differences above were statistically significant (p > 0.05). Furthermore, ways to go to work, exercise time per day, liking exercise before or after pregnancy, and sleep conditions between the control and case groups were about the same (p < 0.05), as shown in Table 9.

Table 9. Comparison of pregnant women’s exercise and sleep conditions between the control and case groups (n, %).

| Items                        | Control Group      | Case Group        | Test Value | p Value |
|------------------------------|--------------------|-------------------|------------|---------|
| Elevator at home             | Yes: 106(52.5)     | No: 88(43.6)      | 0.016      | 0.899   |
| Ways to go to work           | By walking: 26(12.9)| By cars: 135(66.8)| 0.598      | 0.439   |
| TV time per day (h)          | <1: 78(38.6)       | 1–2: 58(28.7)     | 1.282      | 0.391   |
|                             | >2: 64(31.7)       |                   |            |         |
| Phone time per day (h)       | <1: 8(4.0)         | 1–2: 32(15.3)     | 2.069      | 0.355   |
|                             | >2: 47(23.3)       |                   |            |         |
| Exercise time per day (h)    | <0.5: 52(25.7)     | 0.5–1: 9(46.0)    | 2.069      | 0.355   |
|                             | >1: 55(27.2)       |                   |            |         |
| Like to exercise before pregnancy | Yes: 56(27.7)  | No: 144(71.3)     | 0.055      | 0.814   |
| Like to exercise after pregnancy | Yes: 68(33.7)  | No: 131(64.9)     | 0.027      | 0.869   |
| Sleeping time (h)            | <8: 21(10.4)       | ≥8: 171(84.7)     | 0.088      | 0.767   |
|                             | 8: 35(37.6)        |                   | 1.218      | 0.749   |
| Sleeping quality             | Well: 88(43.6)     | Better: 64(31.7)  | 0.041      | 0.816   |
|                             | Normal: 44(21.8)   | Bad: 6(3.0)       | 1.218      | 0.749   |

Note: Some of the variables had missing values.
Variables with a $p$ value less than 0.05 in the univariate analysis were included in the logistic regression analysis. The result showed that having greater than or equal to four meals a day (OR = 6.552, 95%CI = 1.014–42.338) and liking to eat lightly flavored food during pregnancy (OR = 1.887, 95%CI = 1.048–3.395) were independent risk factors of maternal dyslipidemia, as shown in Table 10.

Table 10. Logistic regression analysis of the impact factors of maternal dyslipidemia.

| Items                              | β    | S.E.  | Wald | p Value | OR(95%CI)       |
|------------------------------------|------|-------|------|---------|-----------------|
| Meals per day                      |      |       |      |         |                 |
| 1 time Ref.                        |      |       |      |         |                 |
| 2 times                            | 0.290| 0.814 | 0.127| 0.721   | 1.337(0.271–6.591) |
| 3 times                            | 0.882| 0.828 | 1.136| 0.287   | 2.416(0.477–12.238) |
| ≥4 times                           | 1.880| 0.952 | 3.899| 0.048   | 6.552(1.014–42.338) |
| Like to eat lightly flavored food  |      |       |      |         |                 |
| No Ref.                            |      |       |      |         |                 |
| Yes                                | 0.635| 0.300 | 4.486| 0.034   | 1.887(1.048–3.395) |
| Constant                           | −1.796| 0.823| 4.768| 0.029   | 0.166          |

4. Discussion

We found the prevalence rate of maternal dyslipidemia was 31.5% according to the Williams Obstetrics. A previous study showed that the detection rates of maternal dyslipidemia varies greatly by different criteria [12]. This was consistent with our findings as we found the prevalence rate of maternal dyslipidemia was 5.2% by self-report, obviously lower than 31.5%. We concluded that current society often ignores abnormal blood lipid levels during pregnancy as the self-report rate of dyslipidemia was obviously lower. This phenomenon should arouse our attention and health education in this field should be strengthened from now on.

We found birth weight was affected by abnormal TG levels of pregnant women, which agreed with the results of many studies [13–15]. In our study, the median levels of TG/HDL ratio were higher in LGA newborns, which agreed with the study that found the TG/HDL ratio showed an obvious dose-dependent relationship with the occurrence of macrosomia [16]. Consistent with our result, most studies had not found relationships between maternal serum TC and LDL levels and birth weight [13,16]. Weight in early life was highly associated with weight and quality of life in children, adolescents and adults [17–19]. We concluded that TG levels in the third trimester of pregnancy could influence infants’ height and weight indirectly through the influence of birth weight, as the birth weight was positively related to infants’ height and weight at six months and one year old. The number of adipocytes would no longer decrease once they were formed, leading to obesity in children at a younger age, which could represent a hidden danger of being overweight or obese in the future [20]. Therefore, blood lipid levels of pregnant women should be as much a concern during pregnancy as blood sugar levels.

Leptin could lead to an increase in triglyceride hydrolysis and a suppression of lipogenesis and in vivo studies have obviously demonstrated that leptin can reduce body fat mass [21]. Our study showed that leptin in cord blood was positively correlated with the maternal serum TG levels in the third trimester of pregnancy and birth weight of fetuses, but was not directly related to infants’ weight at six months and one year old, consistent with Hauguel-de Mouzon, S.’s findings [22]. This indicates that high TG levels in the third trimester of pregnancy would promote the synthesis of leptin in mothers, and then it would be transmitted into the umbilical cord blood, which would eventually have a direct impact on the growth and development of fetuses. Later, the leptin in the cord blood would indirectly affect the physical development of infants after birth as birth weight was positively related to infants’ height and weight at six months and one year old. The formation of leptin receptors in fetuses could be influenced by the leptin in cord
blood, therefore, the leptin receptor gene was considered a biological pathway related to childhood obesity development [23,24].

The influencing factors of gestational dyslipidemia in the third trimester of pregnancy were explored. Studies have reported that the maternal lipid levels were affected by maternal age, BMI before pregnancy and weight gain during pregnancy [25–27]. However, these relationships were not found in our study. Therefore, the baseline information of the two groups of pregnant women was consistent. A nutrient-rich maternal diet during pregnancy was essential to pregnant women’s health and fetuses’ development [28]. However, diets with high sugar, high saturated fat and an unreasonable proportion of processed food might increase the risk of adverse pregnancy outcomes [29–31]. Interestingly, the results of this study showed no relationship between maternal dyslipidemia and the food intake frequencies or the habit of eating and drinking a lot. We could see the ‘barely intake’ frequencies of relatively unhealthy food, such as canned food, barbecue, fried food, puffed food, beverages and coffee, were higher than 85% in both control and case groups of pregnant women. The dietary habits of pregnant women were healthy while they tended to eat breakfast regularly, eat meals on time, drink boiled water other than sweet drinks, and so on. The vigorous propaganda about the hazards of high sugar, high saturated fat and processed food and the self-protection awareness of pregnant women might explain this phenomenon. Meanwhile, there were no statistically significant differences in exercise and sleep conditions of pregnant women between the control and case groups, however, we still found they tended to spend more time on TV and phones and less time doing exercise on the whole. As exercise and sleep conditions could influence blood lipid levels, this phenomenon should arouse our attention [32,33].

Logistic regression analysis showed that having greater than or equal to four meals a day and liking to eat lightly flavored food during pregnancy were independent risk factors for maternal dyslipidemia in the third trimester of pregnancy. Although liking to eat lightly flavored food during pregnancy was good for health, it might lead to a lack of protein and excessive carbohydrate intake. If the energy exceeded the body’s needs, carbohydrate-decomposed sugar would be converted into fat in the liver, leading to increased blood lipid levels in pregnant women [34,35]. Our results showed that the intake frequency of staple foods, vegetables and fruits of at least once a day reached around 80%, while the intake frequency of lean meat, eggs and milk products of at least once a day was only about 50%. Furthermore, the intake frequencies of seafoods and liver were not enough either. The digestive system would stimulate the body to eat more carbohydrates or increase the number of meals if the intake of protein and fat was insufficient, as they could bring a feeling of fullness and prolong the emptying time of the stomach [36–38]. Eating a light diet may reduce satiety, and lead to an increase in the number of meals and excessive intake of carbohydrates, which will eventually lead to maternal dyslipidemia. Thus, we should strengthen the guidance of dietary balance during pregnancy to prevent the occurrence of maternal dyslipidemia in the future.

Our study indicated that there was a positive relationship of maternal dyslipidemia during late gestation and the birth index and infants’ development as it was a population-based bidirectional cohort study. However, the follow-up bias was inevitable. Our research showed that the number of meals per day and preferring lightly flavored food during pregnancy might be risk factors for maternal dyslipidemia. Another limitation of our investigation was that the intake of various foods during pregnancy was not quantified, and it was impossible to compare the energy supply proportions of the three major macronutrients.

5. Conclusions

Transient mild dyslipidemia during pregnancy could steadily return to normal after delivery, while more serious dyslipidemia was difficult to correct [39]. Dyslipidemia in pregnant women could affect birth weight by increasing leptin levels in cord blood, and then influencing the physical development of young children. Thus, we should strengthen
the monitoring of blood lipid levels of women during pregnancy. The habits of diet during pregnancy were basically reasonable under vigorous publicity, but the implementation of dietary balance still needed more guidance.

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Data Availability Statement: All datasets generated during and analyzed during the current study are not publicly available but are available from the corresponding author on reasonable request.

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