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Preliminary Results Concerning Investigation of Air Pollution Effect in Western Macedonia on Fasting Blood Glucose during Pregnancy

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Abstract

Pregnancy is very crucial period in a woman's life. Several changes occur in her body in order to supply the best to the fetus. During pregnancy glucose metabolism undergoes specific adaptations, including increased hepatic glucose production in the fasting state and maternal peripheral insulin resistance, so that glucose is always supplied to the fetus. PM pollution has recently been suggested as an emerging risk factor for glucose control disorders including impaired glucose regulation, or even diabetes. The aim of the present study was to investigate changes in fasting glucose in pregnant women, associated with changes in exposure to ambient air pollution. 50 pregnant women residents of Kozani, Western Macedonia, Greece participated in the study. The results of the study showed increased levels of fasting blood glucose in most women. Moreover, according to simple linear correlation (Pearson's test), PM2.5 levels were associated with increased fasting blood glucose. The statistically significant correlation between atmospheric pollution and glucose levels found in the present preliminary study shows a possible role of pollution as a risk factor for second semester glucemia during pregnancy. Therefore future work is considered necessary in order to clarify this possible connection.

Keywords: pollution; biomarkers; pregnancy; fasting blood glucose.

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1. Introduction

Lignite is a conventional fossil fuel for electricity generation, while its combustion mainly leads to hydrocarbon, heavy metal and radionuclide release [1]. 100 grams of hydrocarbons per tonne of carbon are produced by combustion, most of which are polyaromatic hydrocarbons. The lignite ash from the combustion of lignite accounts for 95% of the total ash produced. A large percentage of the ash is often transported with gas from the chimneys, and distributed in soil, since the electrostatic filters used have limited absorption for ash [2]. Heavy metal emissions as a result of combustion of lignite in power plants have been the subject of several studies [3, 4].

75% of lignite production in Greece is perfomed in West Macedonia Lignite Center (WMLC). There are four thermoelectric power plants of 4 GW installed capacity in total, generating approximately 70% of the entire electricity production in Greece [5]. Lignite reserves in this area are estimated to be around 3,300,000 tons, equivalent to 455,000,000 tons of oil. Because of these activities, the possibility of emitting PAHs and various metals into the atmosphere and their subsequent deposition into the soil has been particularly studied. The studied area, from an environmental point of view, is considered one of the most underdeveloped in Greece. Measurements in this area have shown high levels of SO and NO, especially during winter and spring when the prevailing winds are weak to hold them [6].

Power plant emissions are composed of black (elemental) carbon, organic carbon, sulfates, nitrates, metals, dust, and biological material, released as particulate matter (PM) with diameter less than or equal to 1μm, (PM1) 2.5μm (PM2.5) or 10μm (PM10). Because of their small size, they easily enter the bronchi and alveoli [7]. Therefore, the population is experiencing respiratory problems, such as chronic bronchitis [8], that in some cases require even the abandonment of villages or inhabited areas. Moreover, PM has been associated with local and systemic inflammation and adverse cardiorespiratory outcomes [9]. Increased systemic inflammation was previously observed even in pregnant women after their exposure to higher PM2.5, implying that effects of particulate air pollution on adverse birth outcomes may be mediated by systemic inflammation [10].

PM pollution has recently been suggested as an emerging risk factor for glucose control disorders including impaired glucose regulation [11], or even diabetes [12, 13, 14]. However, it is still not clear what is the biological mechanism underlying the association between PM and glycemia. As far as pregnant women are concerned, glucose metabolism undergoes specific adaptations during pregnancy, so that glucose is always supplied to the fetus [15]. These adaptations include increased hepatic glucose production in the fasting state, to ensure a continuous glucose supply, and maternal peripheral insulin resistance, to accomplish glucose transfer to the fetus [16]. Thus, the maternal-to-fetal glucose flux is mostly dictated by the maternal-to-fetal glucose concentration gradient, i.e. the glucose concentration difference between the maternal and fetal compartments. All the above make the study of glucose levels both in mother and in fetus crucial for avoiding perinatal clinical outcomes. The aim of the present study was to investigate changes in fasting glucose in pregnant women, associated with changes in exposure to ambient air pollution, supporting it as a pollution biomarker. Moreover, the preliminary results of the current work intend to offer a health effect in order to avoid possible perinatal clinical outcomes.

2. Materials and Methods

2.1. Study population

50 pregnant women participated in the study. All of them were residents of Kozani, Western Macedonia, Greece. Eligibility criteria included gestational age up to the end of the second trimester, and none of the women was characterized with preexisting type 1 or type 2 diabetes mellitus. All subjects gave written informed consent for participation.

2.2. Fasting blood glucose measurement

Venous blood samples of pregnant women were collected in the morning after an overnight fast of more than 12 hours fasting glucose. Blood glucose levels were analyzed using the enzymatic hexokinase method. According to American Diabetes Association criteria, FBG less than 100 mg/dL corresponds to normal levels and the 100–125 mg/dL range to impaired fasting blood glucose (IFG), which in older individuals often progresses to diabetes over time. FBG larger than 125 mg/dL is defined as clinical diabetes [17]. Moreover, the values measured in pregnant women were analyzed based on the normal values during pregnancy, given in Table 1.

Table 1: Reference values of fasting glucose during pregnancy [18, 19, 20].

Glucose, fasting (Plasma)				
Units	Non pregnant Adult	First Trimester	Second Trimester	Third Trimester
mg/dL	75 - 99	-	75 - 80	71 - 77
mmol/L	4.2 - 5.5	-	4.2 - 4.4	4 - 4.3

Pregnant women with a fasting plasma glucose greater than or equal to 5.1 mmol/l (92 mg/dl) but less than 7.0 mmol/l (126 mg/dl) may be diagnosed with gestational diabetes (GDM).

A fasting plasma glucose greater than or equal to 7.0 mmol/l (126 mg/dl) identifies women with overt diabetes.

2.3. Air pollution data

All data of air pollution were obtained from the Laboratory of Atmospheric Pollution and Environmental Physics (LAPEP) of Technological Educational Institute of Western Macedonia. Data for PM10, PM2.5 and PM1 were expressed as $\mu g/m^3$.

2.4. Statistical analysis

Simple linear correlation (Pearson's test) conducted with mean values was used to establish significant relationships between fast blood glucose values and PM10, PM2.5 and PM1 values respectively. The analysis was carriedout using STATISTICA 13 (STATISTICA, Microsoft Co.).

3. Results

3.1. Fasting blood glucose analysis

Blood samples were collected at a mean of 17 gestational weeks. Increased levels of fasting blood glucose were measured in most women, with a mean of 79,55±11,542 mg/dl (Figure 1).

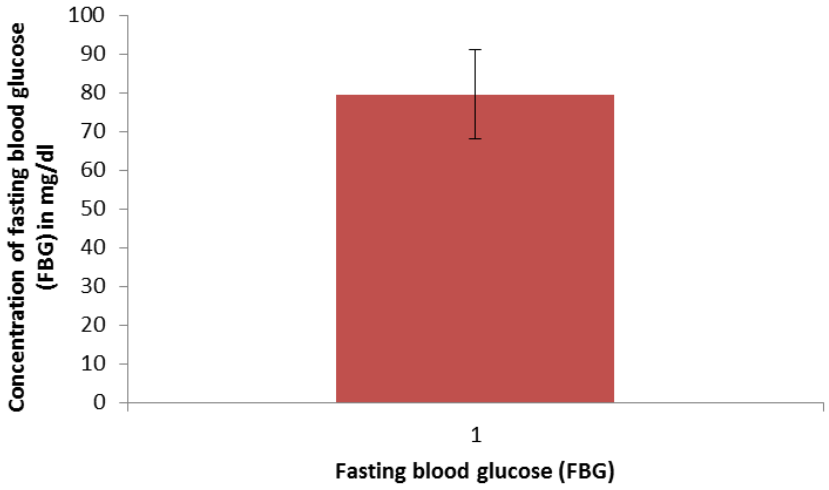

Figure 1: Concentration of fasting blood glucose (FBG) measured in 50 pregnant women using the enzymatic hexokinase method.

3.2. PM analysis

Analysis of air pollution indicated relatively high levels of PM. More specifically, the mean concentration of PM were 4,96 ± 0,832 for PM1, 11 ± 0,714 for PM2,5 and 18,92 ± 1,66 for PM10 (Figure 2).

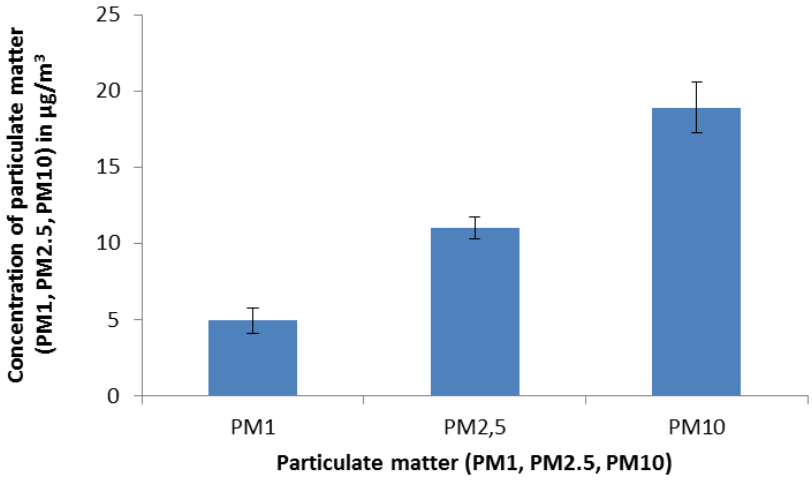

Figure 2: Summary statistics of PM1, PM2.5 and PM10 daily air pollution levels during study period.

3.3. Associations between air pollution and blood glucose

According to simple linear correlation (Pearson's test), PM2.5 levels were associated with increased fasting blood glucose.

4. Discussion

The preliminary results of the present study showed relatively increased levels of FBG in most pregnant women, with values being close to the upper normal limit observed at the end of the second trimester. Moreover, statistical analysis showed a significant correlation between FBG values and atmospheric PM2.5, while not with PM1 or PM10. Alterations in glucose levels have previously been linked to air pollution. However, limited data is published on the effect of the specific pollutants on glucose metabolism. Previous studies indicated that ambient PM is associated with metabolic dysregulation [12]. Fasting serum glucose has been associated with ozone or PM10 levels [21]. Our results are consistent with the ones of previous studies supporting associations between FBG and PM2.5 or PM10 in nondiabetic individuals living in polluted areas [22, 23, 24]. In comparison with the results of the current work, Malmqvist and his colleagues [25] reported dose–response associations between NOx and GDM, while Fleisch and his colleagues [7] reported positive association between second-trimester PM2.5 exposure with impared glucose tolerance, but not with GDM, supporting that particular matter smaller than 2.5 mm in diameter (PM2.5) may promote insulin resistance. The insulin resistance has previously been explained with a possible promotion of inflammatory response caused by air pollutants, which may disrupt glucose metabolism process and insulin signal transduction pathway [21, 26, 27]. Increased inflammation response has also been reported in pregnant women after exposure to PM2.5 [10]. Inflammation is a common situation often appearing during pregnancy and is usually attributed to insulin resistance. This insulin resistance may be part of the normal physiological adaptation to ensure glucose transfer to the fetus, then causing abnormal glycemia of the mother [28]. Therefore Buchanan and Xiang [29] supported that glycemia may result either to impaired glucose tolerance (IGT) or even gestational diabetes mellitus (GDM) causing further problems to mother and fetus.

The association between air pollution exposure and these outcomes has become the subject of a growing number of studies [25, 7, 30, 31]. PM have previously been considered as a causing factor of oxidative stress and generation of systemic inflammation [32], and more specifically of adipose tissue inflammation. This is probably due to insulin signaling abnormalities, which could lead to insulin resistance [21, 26]. Oxidative stress has been shown to be involved both in insulin secretion and insulin action [21]. Also, hyperglycemia has been noted to promote oxidative stress through de novo free radical generation and suppression of the antioxidant defense systems. In chronic hyperglycaemic conditions, production of ROS is perpetuated and hence, the antioxidant enzymes and non enzymatic antioxidants are severely suppressed in various tissues, which further exacerbate oxidative stress [33]. Therefore, during pregnancy, pollutants may enhance the effect of existing insulin resistance, causing further inflammation on mother. The biological plausibility of air pollution (specifically fine particulate matter) affecting health has been discussed by Pope and Dockery [34], focusing on hypothesized biological pathways comprise systemic inflammation and placental oxidative stress [35].

Our findings of PM2.5 associations with FBG in pregnant women living in polluted areas may help identify pregnant women who are particularly susceptible to changes in FBG in the nondiabetic range. It is important to notice that most values of FBG were close to 80 mg/dl and therefore a very small change in FBG may be enough to pass the threshold. In conclusion, the results of this preliminary study may offer a health effect both on a population of pregnant women and individual levels. Since the whole population of the wider region of Kozani is exposed, even small effects may lead to substantial health outcomes. On an individual level, chronic exposure to pollution may have different outcomes on each person. Cumulative lifetime risk is probably larger than acute exposure, since it is related to a combination of exposure intensity and duration.

It should be outlined that abnormal levels of glucose, even at mild degrees, have been associated with perinatal clinical outcomes [36]. Moreover, this glycaemia may contribute to future obesity and insulin resistance in both mother and offspring [37]. Finally, a limitation of the study was the size of the sample, which contained 50 pregnant women.

5. Conclusion

The statistically significant correlation between atmospheric pollution and glucose levels found in the present preliminary study shows a possible role of pollution as a risk factor for second semester glucemia during pregnancy. Therefore future work is considered necessary in order to clarify this possible connection.

6. Recommendations

The present study focused on investigating the correlation between air pollution and fasting glucose levels at the end of second semester of pregnancy. Therefore, future research could focus on examining fasting glucose levels at several different times during pregnancy, i.e. during first or third semester, in order to acquire an integrated view of the effect of air pollution during the whole pregnancy. Moreover, further research could take place on studying more air pollutants and their effects on pregnancy.

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