

Correlation Between Maternal Body Mass Index, Non-stress Test Parameters and Pregnancy Outcomes in Nulliparous Women

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Background: An increase in maternal body mass index (BMI) before pregnancy can cause overweight during pregnancy, and negatively affect both the mother and the fetus. Non-stress test (NST) is the most common way to evaluate the fetus during pregnancy.

Objectives: This study aimed to evaluate the correlation between maternal BMI and NST parameters as well as the pregnancy outcomes in nulliparous women.

Materials and Methods: This case-control study, comprised 67 nulliparous women with the gestational age of 24-28 weeks, selected by simple random sampling, who were admitted to Shooshtari and Hafez hospitals from 2011 to 2012. The case group included 35 pregnant women with BMI greater than 26. The control group consisted of 32 pregnant women with BMI lower than 26. NST was applied to groups and evaluated reactive and non-reactive parameters, basal fetal heart rate, and number of accelerations. Chi-square test was used to examine the reactive and non-reactive parameters and type of delivery. Other variables were statistically analyzed using 1-way analysis of variance (ANOVA).

Results: Our results indicated that the frequency of NST reactive and non-reactive parameters was 41%, 59% in the case group, respectively and 55%, 45% in the control group, respectively. Besides, a significant difference was found between the case and the control group regarding reactive parameters ($P = 0.02$). However, no significant difference was observed between the two groups concerning the mean of basal fetal heart rate ($P = 0.3$). However, the number of accelerations in the case group was significantly lower than that of the control group ($P = 0.001$). Significant increases were found in the case group regarding the mean of post-delivery weight ($P = 0.02$), BMI after delivery ($P = 0.005$), neonatal birth weight ($P = 0.001$), gestational age ($P = 0.001$), and caesarian section (CS) delivery ($P = 0.01$).

Conclusions: This study revealed that the increase in maternal BMI was accompanied by a decrease in non-reactive parameters of NST and the number of accelerations of the fetal heart rate which is the most important index for fetal health. Also, a significant increase was observed regarding maternal BMI one month after delivery, neonatal birth weight, gestational age, and CS delivery.

Keywords: BMI; Fetal Heart Accelerations; FHR; Non-Stress Test

1. Background

Obesity is considered as a major health problem all over the world. The prevalence of overweight and obesity in Iranian women is 28% and 25%, respectively. Pregnancy overweight is correlated with pregnancy diabetes, preeclampsia, delayed fetal growth, and accident-related thromboemboli (1, 2).

During pregnancy, BMI between 26 and 29 kg/m² is considered as overweight and values greater than 29 are regarded as obesity (3). Cathaline et al. reported that increase in BMI during pregnancy is correlated with an increase in post-delivery weight, use of oxytocin, and arrest in the active phase of labor (4).

Maternal obesity can be responsible for pregnancy adverse effects. Obese pregnant women are more prone to pregnancy diabetes, preeclampsia, vaginal infection accompanied by surgical interventions, and CS delivery (5). Besides, they are more susceptible to wound infection and endometritis. Their babies are also more prone to birth

defects, macrosomia, and morbidity due to childhood obesity (6). The results of a survey indicated that the possibility of preeclampsia in a pregnant woman was twice for each 5-7 kg/m² increase in BMI (7). Pregnant women with high BMI suffer from parturition-neonatal complications two times more than those with lower BMI levels (8). These complications include macrosomia (heavier than 4500 g), defective presentation, increase in CS delivery, and infant hospitalization (9). Maternal obesity can also increase the risk of structural anomalies such as fetal heart defects (10). Studies have revealed a positive correlation between maternal obesity and fetal heart rate in the second trimester (11). Moreover, Tworetzky et al. reported that maternal obesity would result in increased risk of fetal heart defects, such as VSD, ASD, and aortic defects (12).

NST is the most common test for evaluating the fetal health status before labor. Freeman et al. considered the number of accelerations as an index of fetal health. NST,

with the use of Doppler technique, can assess the number of accelerations as the mother feels the movement of the fetus (13). According to NST principle, the number of fetal heart rate accelerates transiently in response to fetal movements in the fetuses who do not suffer from acidosis due to hypoxia or neurologic depression (14).

2. Objectives

Up to now, only few studies have assessed the effect of maternal BMI during pregnancy on the NST parameters. Thus, the present study aimed to evaluate the correlation between maternal BMI and NST parameters, including numbers of accelerations, basal heart rate, and reactive or non-reactive parameters and the pregnancy outcomes (average of maternal weight after delivery, neonatal birth weight, gestational age, and type of delivery) in nulliparous women.

3. Materials and Methods

In this case-control study, 67 nulliparous women with the gestational age of 28-34 weeks admitted to Shoosh-tari and Hafez hospitals from 2011 to 2012 were selected using simple random sampling. The case group included 35 pregnant women with BMI greater than 26 kg/m². The control group consisted of 32 pregnant women with BMI lower than 26 kg/m². The calculation of sample size was made by the following formula:

$$\frac{2 \left(Z_{1-\frac{\alpha}{2}} + Z_{1-\beta} \right) \delta'}{r}$$

Where $\sigma_1 = \sigma_2$, $d = 2$, $\alpha = 0.05$, and $\beta = 0.1$. It involved the variance of 0.92, the minimum difference mean 0.6, type I error equal to 5%, and the power equal to 80%, with the significance level considered as $P < 0.05$.

BMI was calculated by dividing weight in kilograms by height in meters squared. NST was applied at the

gestational age of 36-40 weeks for both case and control groups. Chi-square test was used to determine the relationship between reactive/non-reactive parameters and type of delivery, and the relationship between BMI and type of delivery. In addition, the numbers of accelerations, fetal heart rate, mean weight during pregnancy and 1 month after labor, neonatal birth weight, gestational age, and BMI before and after pregnancy were statistically analyzed using t test. Besides, Pearson correlation coefficient was used to investigate the correlation between neonatal birth weight and BMI.

The inclusion criteria of the study were being nulliparous, 18-35 years old, singleton pregnancy with 28-32 weeks of gestation, having no history of threatening factors (preeclampsia, decrease in the number of fetal movements, intrauterine growth limitation, polyhydramnios, oligohydramnios, rupture of membranes more than 12 h, and history of infertility) during the first 28 weeks of pregnancy, having no history of chronic diseases (heart and pulmonary diseases, hypertension, and diabetes), and receiving healthcare services during pregnancy. Recall bias, incomplete, and sometimes incorrect information (which were reflected in the patients' health records) were excluded, because they would cause some limitations to our study.

4. Results

Our results indicated that the frequencies of NST reactive and non-reactive parameters were 41%, 59% in the case group, respectively, and 55%, 45% in the control group, respectively. In this study, a significant difference was found between the case and the control group regarding the reactive parameters ($P = 0.02$). However, no significant difference was observed in the basal fetal heart rate ($P = 0.3$). Furthermore, the number of accelerations in the case group was significantly lower than the control group ($P = 0.001$). BMI before pregnancy was 26 ± 0.21 kg/m² and 22 ± 0.13 kg/m² in the case and the control group, respectively. According to t test a significant difference

Table 1. Demographic Characteristics of Women Under Study^a

Variable	BMI < 26 kg/m ²	BMI > 26 kg/m ²	P Value
Age, y			0.15
18-20	4 (38.9%)	3 (7.1%)	
21-25	8 (26.2%)	18 (52.4%)	
26-30	20 (57.1%)	12 (35.7%)	
31-34	0 (0)	2 (4.8%)	
Education			0.20
Primary school	9 (26.2%)	6 (14.6%)	
Secondary school ^b	5 (17%)	7 (17.1%)	
Diploma ^c	10 (35.7%)	12 (36.6%)	
University degree	8 (21%)	10 (31.7%)	

^a Data are presented as No. (%).

^b Secondary school up to 9 classes.

^c Diploma up to 12 classes.

Table 2. NST Parameters in Women Under the Study^a

	BMI < 26 kg/m ²	BMI > 26 kg/m ²	P Value
Reactive NST	18 (55%)	14 (41%)	0.02
Non-reactive NST	14 (45%)	21 (59%)	0.02
Basal fetal heart rate	138 ± 0.45	136 ± 0.32	0.3
Number of accelerations	3 ± 0.38	1 ± 0.33	0.001

^a Data are presented as mean ± SD. or No. (%).

Table 3. The Parameters Related to Maternal BMI^a

Group	BMI < 26 kg/m ²	BMI > 26 kg/m ²	P Value
BMI before pregnancy	22 ± 0.13	26 ± 0.21	0.02
Mean weight during pregnancy/Kg	65 ± 10	79 ± 8	0.002
Mean weight a month after pregnancy/ Kg	55 ± 9	91 ± 10	0.005
BMI a month after pregnancy/ kg/m ²	20 ± 0.52	31 ± 0.41	0.005
Neonatal birth weight/g	3108 ± 23	4085 ± 25	0.001
Gestational age/week	38 ± 2.2	40 ± 1.2	0.01

^a Data are presented as mean ± SD.

Table 4. The Kind of Delivery Related to Maternal BMI^a

Type of parturition	BMI < 26 kg/m ²	BMI > 26 kg/m ²	P Value
Normal vaginal delivery	58 (87%)	31 (46.8%)	0.01
Cesarean section	9 (13%)	36 (53.2%)	0.01

^a Data are presented as No. (%).

was found between the post-delivery and pre-pregnancy BMI ($P = 0.02$). Moreover, the mean weight during pregnancy in the case and the control group was 79 ± 8 kg, and 65 ± 10 kg, respectively. Also a significant difference was observed between the two groups regarding the weight gain pattern ($P = 0.002$). The mean weight one month after labor was 91 ± 10 kg for the case group and 55 ± 9 kg for the control group, and the difference was statistically significant ($P = 0.005$). Neonatal birth weight was 4085 ± 25 g in the case group and 3108 ± 23 g in the control group, which were statistically significant ($P = 0.001$). Pearson test ($r = 1$) showed a correlation between the neonatal birth weight and maternal BMI during pregnancy ($P = 0.02$). In this study, the gestational age was 40 ± 1.2 and 38 ± 2.2 week in the case and the control group, respectively. The results of Fisher exact and t test showed a significant increase in the gestational age in the case group ($P = 0.001$). The respective frequencies of CS delivery in the case and the control group were 53.2% and 13%, respectively. The results of chi-square test revealed that the frequency of CS delivery was significantly higher in the case group compared with the control group ($P = 0.01$). Also a significant relationship was found between BMI in pregnancy and type of delivery ($P = 0.001$) (Tables 1 - 4).

5. Discussion

Maternal obesity can be accompanied by parturition

complications. The results of this study showed that pregnancy overweight and obesity could decrease the reactive parameters of NST and the number of fetal heart rate accelerations. To evaluate the effect of obesity on the evolution of sympathetic and parasympathetic nervous system, the effect of the obesity in the cardiovascular system must be considered.

Our findings revealed a significant difference between the case and the control group regarding the reactive parameters of NST. In other words, NST parameters were more probable to be non-reactive for the case group. Moreover, the number of accelerations was significantly lower in the case group compared with the control group. Biochemically, an increase in the maternal BMI during pregnancy increases the plasma levels of the acute phase inflammatory mediators such as CRP and IL6, which can easily pass through the placenta to reach the fetal blood circulation. These inflammatory mediators can form microscopic atherosclerotic plugs in the vessels of the fetus and, consequently, affect its cardiovascular indices (13). Obesity can also influence the maternal blood pressure. Kivimaki et al. investigated 1066 women between 24 and 39 years old with BMI greater than 26 kg/m^2 in Finland. They found that these women suffered high levels of TG and LDL as well as high systolic and diastolic blood pressure (14). In addition, Bertias et al. reported that obese women were more prone to preeclampsia during preg-

nancy (15). Furthermore, studies suggest that the onset of coronary artery diseases is from the fetal period. Maternal obesity can dramatically cause metabolic changes in the fetus which can affect its health (16). This result is congruent with the findings of the studies conducted on obese pregnant animals (17).

Maternal obesity causes fetal heart anomalies. Queisser et al. reported that the prevalence of fetal heart anomaly in obese pregnant women was 4% higher than that of the normal population. These anomalies are sometimes minor and could not be detected at birth (18). Thus, the relationship between maternal obesity and fetal heart rate might be due to an undiagnosed fetal heart anomaly (19). Unfortunately, only a limited number of studies have been conducted on the effect of maternal obesity on the NST parameters. Therefore, we faced a limitation for comparison of our results with those of other studies.

Based on the aforementioned studies, it seems that the non-reactive parameters of NST are more prevalent among the obese pregnant women. Decrease in the number of accelerations can be suggestive of fetal sympathetic and parasympathetic nervous system malfunction in response to structural and inflammatory factors. Thus, the role of these hormonal and inflammatory factors in fetal cardiovascular disorders is worthy of investigation.

According to other studies, maternal obesity and overweight are associated with the increase in the risk of prenatal complications and even prenatal death. Therefore, monitoring the pregnant women's diet is of utmost importance (20).

Our study revealed that BMI before pregnancy was 26 ± 0.21 kg/m² and 22 ± 0.13 kg/m² in the case and the control group, respectively. Besides, a significant difference was found between post-delivery and pre-pregnancy BMI. In general, the women who start their pregnancy period with greater BMI will experience more weight gain during this period. Our findings were in agreement with the study on 112 pregnant women, which indicated that the women who were overweight before pregnancy experienced greater levels of weight gain during their pregnancy. This showed that pregnancy overweight was strongly correlated with women's weight before pregnancy (21). In addition, it was claimed that the increase in BMI caused post-delivery overweight (22). Similarly, the findings of the current study showed that BMI one month after labor, and the mean weight were significantly greater among the obese women. Moreover, these women will not experience weight loss after delivery, while those with normal BMI will lose the weight that they have gained during pregnancy.

In a study, it was stated that the obese women were more likely to give birth to babies with higher weights (22). This is due to the fact that maternal fat storage is correlated with BMI and neonatal birth weight (23). Sukalich et al. and Cedergren et al. reported that increasing maternal BMI was proportionate to the increase in the neonate's birth weight (3, 24). This is in line with the results of our study, which also showed a correlation between the neo-

natal birth weight and maternal BMI during pregnancy.

Our study showed that the women with BMI > 26 kg/m² had higher gestational age and were more prone to CS delivery. Also as indicated by in the study by Sukalich et al., an increase in the gestational age and CS delivery was associated with the increase in maternal BMI (23). It seems that greater gestational age will lead to an increase in CS delivery. Macrosomia, delayed labor, and first delivery phase arrest can also cause higher rate of CS delivery among the overweight pregnant women (25-28).

Juhasz et al. mentioned that the success of normal vaginal delivery (NVD) after CS delivery was lower in obese pregnant women compared with their counterparts (29). Furthermore, Cedergren et al. reported that the prevalence of preeclampsia, stillbirth, CS delivery, and shoulder dystocia was higher in obese pregnant women. This finding is consistent with the results of the present study (30).

This study revealed that the increase in maternal BMI was accompanied by decrease in the non-reactive parameters of NST and the number of accelerations of the fetal heart, which is the most important index for fetal health and evolution of sympathetic and parasympathetic nervous system. A significant increase was also observed regarding maternal BMI one month after delivery, neonatal birth weight, gestational age, and CS delivery.

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