

The Relationship Between Neck Circumference and Gestational Diabetes Mellitus in Iranian Pregnant Women

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Abstract

Background It is widely assumed that gestational diabetes is one of the most important causes of fetal and maternal and complications, and the predictive factors for this observation are not fully understood. Neck circumference could be deemed as a predictive factor for gestational diabetes. Thus, the aim of present study was to assess the relationship between neck circumference and gestational diabetes.

Methods The study was conducted on 372 Iranian pregnant women. The criteria set by the American Diabetes Association through a 2-hour was used to classify subjects with regard to gestational diabetes. At 14–16 weeks of pregnancy, neck circumference was measured. The maternal and fetal outcomes were measured, too.

Results Gestational diabetes mellitus was developed in 74 women in 24–28 weeks of pregnancy. Neck circumference at 14–16 of pregnancy age was found to be positively correlated with age ($r = 0.18$, $P = \leq 0.0001$), pre-pregnancy weight ($r = 0.45$, $P = \leq 0.0001$), body mass index ($r = 0.46$, $P = \leq 0.0001$), and weight gain during pregnancy ($r = 0.11$, $P = 0.031$). The adjusted logistic regression revealed that neck circumference was a predictor for gestational diabetes mellitus (OR = 1.20; 95% CI = 1.06, 1.34; $P = 0.002$). The ROC analysis depicted that cut-off of neck circumference in indicating gestational diabetes was 34.3 cm, with the sensitivity of 53% and the specificity of 66%.

Conclusion The finding of the present study indicated that a neck circumference ≥ 34.3 cm in Iranian pregnant women can provide as a predictor of gestational diabetes.

Introduction

Gestational diabetes mellitus is presumably an oral glucose intolerance that is first recognized at 24–28 weeks of gestation and can affect 1–14% of pregnancies in the world [1]. The prevalence of gestational diabetes mellitus among Iranian women was reported differently by different scholars. In a systematic review study, the prevalence was reported to range from 3.1 to 18.6% [2]. Moreover, it is worth noting that its prevalence is currently growing worldwide [3, 4]. Nonetheless, the timely prediction of gestational diabetes and the start of an early effective intervention in the first or second trimester may mitigate the risk of gestational diabetes and yield good results for both the fetus and the mother. [5, 6]. It is generally assumed that gestational diabetes could be associated with adverse fetal, infantile, and maternal outcomes such as sustained impairment of glucose tolerance, preeclampsia, macrosomia, neonatal hypoglycemia, neonatal death caused by respiratory distress, and shoulder dystocia [7–10]; thus, it could be regarded as a potential risk factor for the development of metabolic syndrome [11], cardiovascular diseases [12], maternal obesity, and maternal type 2 diabetes after pregnancy [13]. In addition, previous studies have demonstrated gestational diabetes mellitus as a element of metabolic syndrome among pregnant women; hence, it presumably appears that the risk factors for diabetes mellitus and metabolic syndrome are the same [14–16]. The most prevalent risk factors for metabolic syndrome are: waist-to-hip ratio, hip circumference, and waist circumference [17]. Neck circumference was also reported to be a

marker of fat distribution over the trunk and have a clear association with waist-to-hip ratio, waist circumference, body mass index, and glycemic status among non-pregnant women [18, 19]. Neck circumference was also reported to be clearly associated with increased blood free fatty acid levels [20]. It is thought that neck circumference could be a better marker than waist circumference or other marker for the determination of metabolic syndrome and its key features. Its measurement is also convenient and unchangeable, which is a plus [15, 21, 22].

According to Hoebel et al., neck circumference can be a helpful marker for not only metabolic syndrome but also its risk factors including central obesity, insulin resistance, triglycerides, and fasting blood sugar [16]. In the light of these concerns, we can hypothesize that the risk of gestational diabetes can increase among pregnant women with higher neck circumference. The aim of this study was to assess the relationship between neck circumference and gestational diabetes mellitus during the prenatal care visits of pregnant women.

Material And Methods

The ethics committee of Babol University of Medical Science accepted this study (Ethic ID: IR.MUBABOL.HRI.REC.1398.022). The minimum sample size for this study was calculated to be around 411, which was based on the estimated prevalence of 18.6% in Tehran, Iran [23], with a standard score 95%, margin error of 4%, and 15% of drop-out rate.

A total of 411 singleton pregnant women, aged 18–35 years who were at 14–16 weeks of pregnancy, were recruited for this study at prenatal clinics affiliated with Babol University of Medical Sciences. The study was in progress over the period between March 2019 and February 2020. The women with a history of pre-gestational diabetes ($n = 11$), dyslipidemia ($n = 2$), chronic hypertension ($n = 4$), thyroid disease ($n = 6$) and other endocrine diseases ($n = 2$), fetal malformations in nuchal translucency (NT) ($n = 2$), and taking hyperglycemic drugs (corticosteroids and thyroid hormones) ($n = 1$) were excluded of our study. 24 women were initially excluded from the study, which was based on the results of the routine prenatal blood tests at the first trimester of pregnancy as well as the information obtained from their medical documents. Therefore, the remaining 387 eligible women signed the written informed consent forms. The data for all pregnant women were collected at three time-points: 14–16 gestational weeks, 24–28 weeks, and after the child birth. During the follow-up, 15 participants with diagnosed pregnancy-induced hypertension and gland thyroid disease were also excluded from the study.

During the 14–16 weeks of pregnancy, the characteristics of the participants such as age, gravidity, and parity were obtained. The women were requested to report the pre-pregnancy weight (self-report). If the woman did not remember the weight before pregnancy, the weight of the first visit (first trimester of pregnancy) was recorded. The gestational age of the participants was defined according to last menstrual period and established by early ultrasound pregnancy. The height was measured with a tape measure without shoes. The body mass index was measured by the subsequent formula: weight (kg)/

squared (m^2). The neck circumference was determined through a tape from the level just below the larynx (accuracy 1 cm) with subjects standing position, straight ahead with their shoulders [24].

At 24–28 weeks of pregnancy, the blood pressure (BP) was measured with calibrated mercury sphygmomanometers with appropriate size cuffs after the women had rested for 15 minutes. The Korotkoff phase 1 (first sound) and Korotkoff phase 5 (fifth phase) of blood pressure was defined as systolic blood pressure and diastolic blood pressure, respectively [25]. Pregnancy induced hypertension (PIH) was defined as blood pressure greater than or equal to 140/90 mmHg with or without proteinuria during pregnancy [26].

In addition, a two-hour, 75-gram oral glucose tolerance test (OGTT) was performed after a ten-hour fasting in sitting position. All blood samples were analyzed at laboratories affiliated with Babol University of Medical Sciences. If there were any of the following glucose cut-off levels: fasting ≥ 92 mg/dl or one-hour ≥ 180 mg/dl or and two-hour ≥ 153 mg/dl, the women were diagnosed with gestational diabetes [27].

Out of 387 women who were followed until child birth, 15 women with diagnosed pregnancy-induced hypertension and gland thyroid disease were excluded from the study for the accurate assessment of the relationship between neck circumference and gestational diabetes. In addition, the maternal weight at the end of pregnancy, the type of birth, the weight of the newborn, respiratory syndrome, and the administration in the neonatal intensive-care unit (NICU) were all collected from the records of delivery.

Statistical analysis

Analyses were performed by SPSS software version 20.0 (SPSS Inc, Chicago, IL, USA). The Kolmogorov-Smirnoff test was used as a test for evaluating the normality of the dataset. The demographic and anthropometric characteristics, blood pressure and blood glucose (gestational diabetes mellitus) were compared between the two groups using independent t-test and chi-square test. Correlation between neck circumference and risk factors of gestational diabetes mellitus was assessed by Pearson coefficient test. Adjusted age logistic regression analysis was used for present odds ratio (OR) and confidence interval (95% CI).

Also, ROC analysis was used to evaluate the predictability of gestational diabetes. The area under the curve was calculated by SPSS software, and with due sensitivity and specificity, we strove to obtain the best neck circumference cut-off points. The significance level for all tests was considered less than 0.05.

Results

This study included 372 participants with a mean age of 28.1 ± 4.4 years. The participants had a mean height, weight, and body mass index of 162.0 ± 5.6 cm, 69.9 ± 9.9 kg, 26.6 ± 3.4 kg/ m^2 , respectively. The mean neck circumference was calculated to be 34.3 ± 2.3 cm at 14–16 weeks of pregnancy. According to the criteria set by the American Diabetes Association through two-hour [27], gestational diabetes mellitus

was diagnosed in 74 of the participants; consequently, the participants were classified into two groups: the women with gestational diabetes (n = 74), as a case group, and those with normal pregnancies, without gestational diabetes (n = 298), as a control group. It is worth noting that the mean gravidity, parity, neck circumferences, and pregnancy body mass indices were significantly higher in women with gestation diabetes compared with those of the normal group. Also, women with gestational diabetes had significantly increased fasting blood sugar, OGTT one-hour Glucose, and OGTT two-hour Glucose than those who were normal group (Table 1).

Table 1
Characteristics of the participants by the gestational diabetes mellitus

Variables	Gestational Diabetes Mellitus	Normal	p-value
	N = 74	Mean \pm SD	
	Mean \pm SD	N = 298 Mean \pm SD	
Age (years)	161.7 \pm 0.5	162.1 \pm 5.7	0.578
Gravidity	2.1 (1.0)	1.8 (1.0)	0.007
Parity	1.0 (0.7)	1.0 (10)	0.064
Pre-pregnancy weight (Kg)	71.6 \pm 10.6	69.5 9.7	0.092
Height (cm)	161.7 \pm 5.0	162.1 \pm 5.7	0.578
BMI	27.4 \pm 4.0	26.4 \pm 3.2	0.045
Neck Circumference	35.1 \pm 2.7	34.1 \pm 2.1	0.005
Systolic BP (mmHg)	110.5 \pm 10.0	108.7 (10.5)	0.180
Diastolic BP (mmHg)	70.2 (8.6)	68.7 (9.2)	0.643
Weight gain during pregnancy (Kg)	11.0 \pm 4.3	11.4 \pm 4.3	0.506
FBS (mg/dl)	106.8 \pm 23.5	81.5 \pm 5.8	\leq 0.0001
1-hour glucose (mg/dl)	124.5 (43.6)	102.4 \pm 17.3	\leq 0.0001
2-hrour glucose (mg/dl)	128.9 \pm 36.9	97.5 \pm 15.2	\leq 0.0001

The results of Pearson correlation depict that neck circumference was significantly correlated with age, pregnancy weight gain, maternal weight pre-pregnancy, and body mass index, (Table 2).

Table 2
Pearson's correlation between neck circumference and risk factors of gestational diabetes mellitus

Variables	r	p-value
Age (years)	0.18	≤ 0.0001
Pre-pregnancy weight (Kg)	0.45	≤ 0.0001
BMI	0.46	≤ 0.0001
Weight gain during pregnancy (Kg)	0.11	0.031

Table 3 shows the estimated adjusted odds ratio (with 95% CI) gestational diabetes with independent variables in pregnant women. There was a significant association found between gestational diabetes and high body mass index, high fasting blood sugar, high 1-hour glucose, 2-hour glucose, and high neck circumference (Table 3). The adjusted logistic regression values of neck circumference and body mass index before pregnancy were 1.20 (95% CI = 1.06, 1.34; P = 0.002) and 1.08 (95% CI = 1.01, 1.16; P = 0.031), respectively.

Table 3
Adjusted* odds ratio for gestational diabetes mellitus and dichotomous variables (n = 372)

Variables	Odds ratio	95% Confidence interval	p-value
Pre-pregnancy weight (Kg)	1.02	1.00–1.05	0.103
BMI	1.08	1.01–1.16	0.031
Weight gain during pregnancy (Kg)	0.97	0.91–1.03	0.266
FBS** (mg/dl)	1.40	1.28–1.53	≤ 0.0001
1-hour glucose (mg/dl)	1.03	1.02–1.04	≤ 0.0001
2-hour glucose (mg/dl)	1.05	1.04–1.06	≤ 0.0001
Neck circumference	1.20	1.06–1.34	0.002
*Adjusted for age			
**FBS: fasting blood glucose			

The ROC analysis demonstrated that the optimal cut-off value of neck circumference and body mass index before pregnancy in gestational diabetes mellitus was 34.3 cm with the sensitivity of 53% and the specificity of 66% and 26.5 kg/m² with the sensitivity of 54% and the specificity of 58%, respectively. Moreover, the area under the curve of neck circumference and body mass index before pregnancy were 0.588 (95% CI 0.509–0.667) and 0.577 (95% CI 0.500–0.654), respectively (Fig. 1).

The frequency for fetal distress syndrome and the administration NICU were significantly higher in subjects with gestational diabetes mellitus than those who were normal group. Also, there were no statistically significant differences between women with and without gestational diabetes in term of delivery type and newborn weight categorization (Table 4).

Table 4
Outcome maternal and neonatal participants by gestational diabetes (n = 372)

Variables	Gestational Diabetes Mellitus N = 74 N (%)	Normal Mean ± SD N = 298 N (%)	p-value
Type of delivery			0.898
Repeated cesarean	29 (39.2)	131 (44.0)	
Elective cesarean	24 (32.4)	89 (29.9)	
Emergency Cesarean	5 (6.8)	17 (5.7)	
Fetal distress syndrome	6 (8.1)	6 (2.0)	0.017
Administration NICU	9 (12.2)	13 (4.4)	0.016
Newborn weight (gr)			0.34
< 2500	2 (2.7)	22 (7.4)	
2500–4000	68 (91.9)	260 (87.2)	
> 4000	4 (5.4)	16 (5.4)	

Discussions

According to the results, we found that the thicker neck circumference could be associated with a higher risk gestational diabetes mellitus in pregnant women (18–35 years old) from Iran. Consistent with our finding, there is a study by Li et al. (2018) conducted on 371 Chinese pregnant women in China (97 diabetic and 274 non-diabetics). They concluded that neck circumference was an independent predictor of gestational diabetes mellitus. The probability of pregnancy risk was also reported at 1.29 using binary logistic regression [28]. In another study, He et al. (2017) conducted a nested case-control study on 255 pregnant women (41 diabetic and 214 non-diabetics), aged 18–35, in China. They depicted that neck circumference predicted gestational diabetes mellitus at 16 weeks of gestation as an independent variable. Therefore, the probability risk for gestational diabetes mellitus was reported to be 1.8, which was slightly higher than that of our study [29].

We also found that neck circumference was positively correlated with all risk factors of gestational diabetes among pregnant women, which was in agreement with the results of previous studies [29, 30].

In contrast to the results of two previous studies on Chinese women [28, 29] and a study on women from Pakistan [30], we found that the calculated cut-point of neck circumference, for predicting of gestational diabetes mellitus, was lower, with varying sensitivity and specificity values. A possible explanation for this discrepancy may be the sample size, the design of the study, and ethnicity.

There were two major limitations in our study. To begin with, all the participants were selected only from prenatal clinics affiliated with Babol University of Medical Sciences. Future studies should be conducted in various centers and on larger samples so that they can provide stronger evidence for this association. Secondly, although most pregnant women had medical documents in these clinics, there is always a possibility of information bias on pre-pregnancy weight of the participants to calculate the pre-pregnancy body mass index, which could have been induced by the self-report of the weight by the participants. This is perhaps a prevalent problem in many other studies as it is hard to measure the weight of women before the outset of the study.

Despite all these limitations, our study used a longitudinal design to assess the relationship between neck circumference and gestational diabetes mellitus and its related risk factors. Thus, the result of this study may be used as a basis for predicting gestational diabetes.

Conclusion

This study illustrated that pregnant women with a neck circumference ≥ 34.3 cm were more likely to develop gestational diabetes. Therefore, applying neck circumference, as a novel index with the obtained cut-off limit, could be useful in preventing gestational diabetes mellitus.

Abbreviations

OGTT
oral glucose tolerance test; ROC: The receiver operating characteristic; NICU: neonatal intensive-care unit; NT: nuchal translucency

Declarations

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Authors' contributions

TSB, MAD, and NA conceived the research idea and designed the Proposal. TSB, ZP, RG, and NA collected data. MAD and TSB analyzed the data. NA and MAD wrote the manuscript. All authors have seen and approved the final version of the manuscript.

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Ethics approval and consent to participate

This research was additionally approved by the ethics committee of Babol University of Medical Sciences (Ethic ID: IR.MUBABOL.HRI.REC.1398.022). Participants in this Study provided written informed consent.

Consent for publication

Not applicable.

Competing interests

There is no conflict of interest between the authors

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Figures

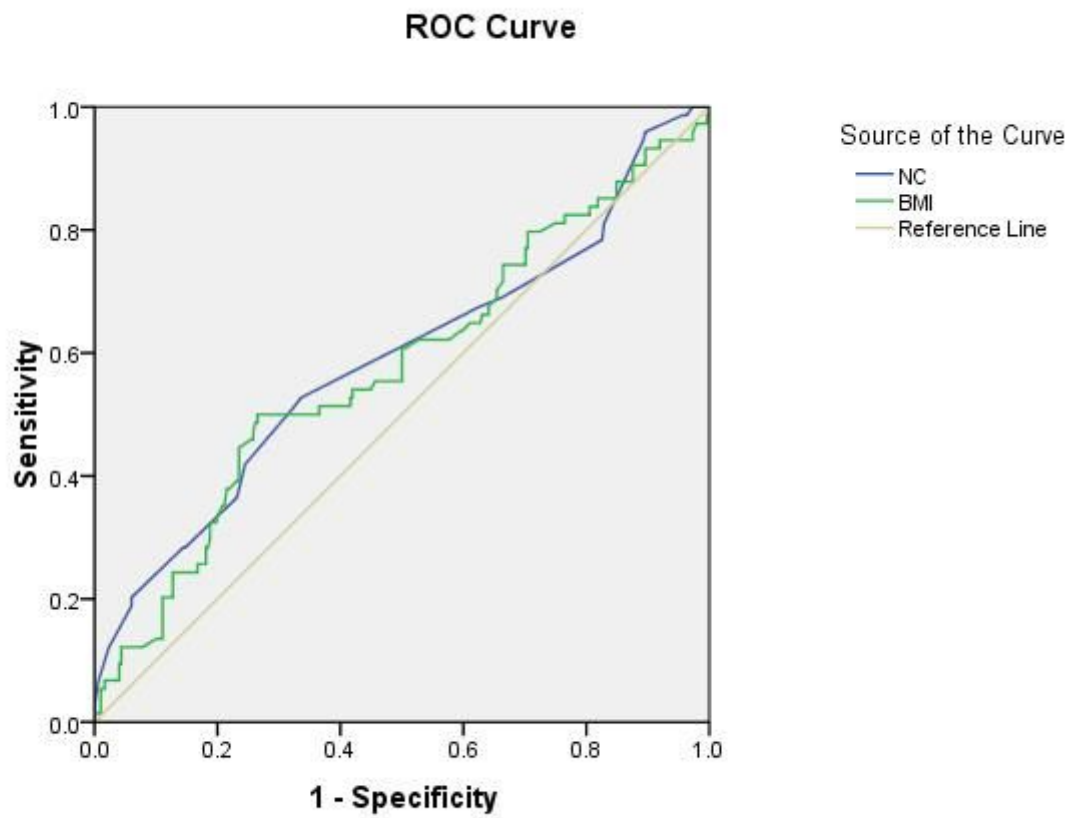


Figure 1

Receiver operating characteristic (ROC) curve of neck circumference (n = 372)