

# Interpretation of maternal blood glucose during pregnancy at high altitude area, Abha-Saudi Arabia

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## ABSTRACT

**Background and Aims:** In women who reside at high altitude, fasting plasma glucose is lower than at sea level, and further decrease of fasting blood glucose was noticed during pregnancy. This study aimed to set cutoff level of fasting plasma glucose during pregnancy at high altitude. The obtained data intended for interpretation of gestational blood sugar results and early detection of those who at risk of developing gestational diabetes. **Methods:** A cross-sectional study was conducted to determine the cutoff level of fasting plasma glucose during pregnancy at high altitude. The subjects were pregnant women who attending the routine antenatal care at Abha Maternity Hospital and Mahayil Aseer Maternity hospital. Plasma glucose concentrations and Body Mass Index (BMI), socio-demographic and obstetric data were entered into the Statistical Package for Social Sciences (SPSS) version 20. Comparison amongst these variables were carried out through t test (numerical variables) and Chi Square test (proportions). A *P* value of <0.05 was considered as statistically significant. **Results:** The overall results obtained indicated that the fasting plasma glucose concentrations and BMI were significantly lower ( $p = 0.0001$ ) at high altitude area (Abha) than low altitude area (Mahayil Aseer). Age was the only socio-demographic factor that showed significant difference between the two groups ( $p$ -value was <0.05). **Conclusion:** Up to our knowledge, this is the first study addressing the interpretation of fasting blood glucose during pregnancy at high altitude area in Saudi Arabia. Our findings support the importance of careful interpretation of fasting blood glucose of pregnant women who reside at high altitude areas. The implementation of this policy at high altitude areas in the Kingdom of Saudi Arabia is recommended for early detection of gestational diabetes and timed intervention to avoid complications.

**Keywords:** Altitude, fasting blood glucose, gestational diabetes, pregnancy

## Introduction

International Society for Mountain Medicine defined high altitude as equal to 1500 m above sea level, the number of populations who lived at this altitude cannot be ignored as around 400 million people in the world lives in this altitude.<sup>[1]</sup>

It has been reported that the fasting plasma glucose levels in women who lives in high altitude areas, is lower than those lives at sea level. Additionally, during pregnancy this level observed

much lower than non-pregnancy status<sup>[2,3]</sup> Due to dilutional effects, fasting blood glucose levels is low in early pregnancy (first trimester) as maternal blood volume increases, while it is reported to be constant in the second trimester, and showing another decrease in the third trimester.<sup>[4,5]</sup>

The relationship between increased BMI and altitude was well explained in different previous studies. It had been documented that the higher the altitude, the lower is the BMI and vice versa.<sup>[6]</sup> This association considers adjustment for multiple risk factors including diabetes.<sup>[6-8]</sup>

Gestational diabetes mellitus (GDM) is a type of diabetes that is peculiar to pregnancy associate with a serious complication to the mother and fetus. Women with GDM are prone to develop

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fetal macrosomia, increase rate of surgical delivery, injuries during labor and maternal diabetes mellitus in the future.<sup>[9]</sup> Therefore, monitoring of fasting blood glucose is important test during antenatal care in addition to diet modifications and exercise, the primary care physician can provide dietary recommendations of caloric allotment and distribution with controlled carbohydrate intake.<sup>[10]</sup>

As at high altitude, the level of fasting blood glucose is low, this test results should be interpreted carefully, upper normal results at low altitude are consider significant at high altitude and needs close follow up to detect GDM earlier, although early screening for gestational diabetes at 14-20 weeks in obese women in recent study did not showed any improvement in the perinatal outcomes.<sup>[11]</sup>

In some studies, it has been found that second and third trimester fasting glucose levels below the cut-off values for the diagnosis of GDM are associated with an increased risk of pregnancy complications.<sup>[12]</sup>

Abha city is located in the Aseer region, Southwestern of Saudi Arabia at an altitude of more than 3000 m above the sea level. The aim of this study is to set a cutoff level of maternal fasting blood glucose at antenatal care clinics different from other low altitude areas in Saudi Arabia to facilitate early detection of GDM, so that the consequent strategies and clinical interventions to avoid the possible complications that may be happen to the mother and the fetus will be adopted.

## Methods

A cross-sectional study conducted at a period from March 2019 to June 2019. The subjects were pregnant women who attending the routine antenatal care clinics at Abha Maternity Hospital (n = 116), which is the major referral, maternity hospital in Aseer region, participants were from Abha, the capital city of Aseer region (3000 m above sea level) and the attendants of antenatal care at Mahayil Aseer Maternity hospital in (n = 97), Mahayil Aseer is 400 m above sea level (low altitude).

### Inclusion criteria

All healthy pregnant women who were free of diabetes and other medical diseases visited the Abha Maternity Hospital and Maternity hospital in Mahayil Aseer during the study duration were included in the study.

### Data collection

Maternal age, gravity, level of education, socioeconomic status and gestational age were recorded through a questionnaire and BMI was calculated for each participant.

After an overnight period of fasting venous blood samples were obtained from all participants who signed informed consent which fulfilled the criteria of research ethics committee of

college of medicine, King Khalid University, Abha, Kingdom of Saudi Arabia. Glucose oxidase/peroxidase method was used to deliver the results.

### Statistical analysis

Plasma glucose concentrations and Body Mass Index (BMI) were compared in addition to socio-demographic and obstetric data, entered into the Statistical Package for Social Sciences (SPSS) version 20. Descriptive and inferential statistics were obtained. Comparison amongst these variables were carried out through t test (numerical variables) and Chi Square test (proportions). A P value of <0.05 was considered as statistically significant.

### Ethics and consent to participate

Ethical Clearance was obtained from King Khalid University Research Ethics committee (REC#2018-06-38) and the participants signed a consent that confirm their willingness to participate in the study.

## Results

The average age of participants at high altitude group was  $28.4 \pm 4.7$  years, which was significantly different from the participant in low altitude group  $27.5 \pm 5.3$  years, (P value = 0.035) [Table 1].

Other maternal characteristics like education, socio-economic status, gravity, and gestational age were not significantly different between high and low altitude groups [Table 1].

The average Body Mass Index (BMI) of high altitude group was lower than high altitude group,  $26.1 \pm 3.01$  (kg/m<sup>2</sup>) Vs

**Table 1: Maternal characteristics**

Variables	High altitude group (Mean±S.D)		Low altitude group (Mean±S.D)		P
	Freq.	%	Freq.	%	
Age (years)	28.4±4.7		27.5±5.3		0.035
Education					
Primary	10	8.6	0	0	0.1
Middle	43	37.1	22	19	
Intermediate	32	27.6	20	17.2	
University	31	26.7	55	47.4	
Socio -economic Status					
3000-6000 SAR	28	24.1	23	19.8	0.169
6001-10,000 SAR	71	61.2	35	30.2	
Above 10,000	17	14.7	39	33.6	
Gravity					
Primigravidae	26	22.4	15	12.9	0.294
Gravida 2-5	38	32.8	10	8.6	
More than 5 deliveries	52	44.8	72	62.1	
Gestational Age					
1 <sup>st</sup> Trimester	57	49.1	53	45.7	0.493
2 <sup>nd</sup> Trimester	31	26.7	34	29.3	
3 <sup>rd</sup> Trimester	28	24.1	10	8.6	

S. D=Standard Deviation; SAR=Saudi Arabia Riyals

29.04 ± 2.53 (kg/m<sup>2</sup>), the difference was statistically significant (P value = 0.0001) [Table 2].

The average fasting blood glucose of pregnant ladies who lives in Abha (high altitude) was 72.5 ± 7.5 mg/dl and this was lower than the average fasting blood glucose of participants from Muhayil Aseer (low altitude) which was found to be 77.9 ± 5.7 mg/dl, this difference was reported to be highly significant (P value = 0.0001) [Table 2].

The highest fasting blood glucose was reported in second trimester of pregnancy (79.7 ± 4.04 mg/dl, 85.44 ± 0.4 mg/dl), followed by third trimester (77 ± 4.11 mg/dl, 79.0 ± 0.001 mg/dl) and the lowest average blood glucose was observed in first trimester of pregnancy (66.5 ± 4.9 mg/dl, 73.01 ± 1.014 mg/dl) for high and low altitude group, respectively. The difference between the 2 groups was approved to be statistically significant (P value = 0.0001) [Table 3].

### Discussion

This is the first study addressing the interpretation of fasting blood glucose during pregnancy at high altitude in Saudi Arabia. Participants (n = 116) living at high altitudes over 3000 m (Abha city) were compared with participants (n = 97) from low altitude area (Mahayil Aseer city).

The average age of pregnant women at high altitude group was 28.4 ± 4.7 years, while the average age of participants from the low altitude group was 27.5 ± 5.3 years (P value = 0.035). Other maternal characteristics including socio-demographic and obstetrics data were similar in both groups.

Although some studies have revealed no significant differences in fasting blood glucose levels between high and low altitude,<sup>[13,14]</sup> our study supports the hypothesis of lower fasting plasma glucose levels during pregnancy at high altitude. A number of studies were in agreement with our findings that showed lower

fasting plasma glucose level in pregnant women living at high altitudes.<sup>[3,15,16]</sup>

Interestingly, the results obtained in the present study observed that fasting blood glucose levels was significantly lower at high altitude in first and third trimester (66.5 ± 4.9 mg/dl, 77 ± 4.11 mg/dl) respectively. These findings can be explained by the haemodilutional effects in the first trimester at high altitude and increased level of insulin in the third trimester.<sup>[4,5,11]</sup> In our settings at Abha, Saudi Arabia no special attention given to interpretation of fasting blood glucose levels during pregnancy, although it is expected to be lower than other low altitude areas in Saudi Arabia. Careful interpretation of fasting blood glucose levels during pregnancy is required at high altitude areas as upper normal levels in these areas should be monitored with caution for a possibility of developing GDM, which necessitates an early clinical intervention to minimize the possible complications.

In the present study, another interesting data was observed. The average BMI of pregnant women high altitude group was significantly lower than at low altitude group, 26.1 ± 3.01 (kg/m<sup>2</sup>) Vs 29.04 ± 2.53 (kg/m<sup>2</sup>), (P value = 0.0001). These results are in line with studies that have shown low prevalence of obesity at high altitude.<sup>[6,17]</sup> The explanation of this relationship until now had been rooming around some theories, the most acceptable one being higher energy expenditure at high altitude.<sup>[13]</sup> On the other hand, it is well known that high BMI is a risk factor for diabetes.<sup>[17]</sup> Pregnant women who attending the antenatal care clinics, especially those with high BMI substantiates a regular follow up for the possibility of GDM, and this is the role of primary care providers. The strategy of detection and initial management of gestational diabetes, apart from increasing workload, can motivate the primary level health care providers.<sup>[18]</sup>

This study's findings of low blood glucose levels at high altitude areas in Saudi Arabia will allow health professionals to develop a new strategic plan to monitor the blood glucose levels in our antenatal care clinics at high altitude areas like Abha for earlier detection of GDM.

### Conclusion

The importance of careful interpretation of fasting blood glucose levels of pregnant women who lives in high altitude areas in Kingdom of Saudi Arabia has been raised by our study. It is high time to develop a new strategy to monitor the blood glucose levels in our antenatal care clinics at high altitude areas

**Table 2: BMI and Fasting Blood Glucose at high and low altitude**

Variables	High altitude group (Mean±S.D)	Low altitude group (Mean±S.D)	P
BMI (kg/m <sup>2</sup> )	26.1±3.01	29.04±2.53	0.0001
Fasting Blood Glucose (mg/dl)	72.5±7.5	77.9±5.7	0.0001

**Table 3: Fasting Blood Glucose per trimesters at high and low altitude**

Trimesters	High Altitude Average Fasting Blood Glucose (mg/dl)	Low Altitude Average Fasting Blood Glucose (mg/dl)	P
1 <sup>st</sup> Trimester (Mean±S.D)	66.5±4.9	73.01±1.014	0.0001
2 <sup>nd</sup> Trimester (Mean±S.D)	79.7±4.04	85.44±0.4	0.0001
3 <sup>rd</sup> Trimester (Mean±S.D)	77±4.11	79.0±0.001	0.0001

S.D=Standard Deviation

like Abha. An earlier detection of GDM and timed clinical intervention to avoid the possible complications to the mother and fetus can be achieved.

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### Conflicts of interest

There are no conflicts of interest.

### References

- Koufakis T, Karras SN, Mustafa OG, Zebekakis P, Kotsa, K. The effects of high altitude on glucose homeostasis, metabolic control, and other diabetes-related parameters: From animal studies to real life. *High Alt Med Biol* 2019;20:1-11.
- Braun B, Mawson JT, Muza SR, Dominick SB, Brooks GA, Horning MA, *et al.* Women at altitude: Carbohydrate utilization during exercise at 4,300 m. *J Appl Physiol* 2000;88:246-56.
- Krampl E, Kametas NA, Zegarra AMC, Roden M, Nicolaidis KH. Maternal plasma glucose at high altitude. *Br J Obstet Gynaecol* 2001;108:254-7.
- Hadden DR, McLaughlin C. Normal and abnormal maternal metabolism during pregnancy. *Semin Fetal Neonatal Med* 2009;14:66-71.
- Angueira AR, Ludvik AE, Reddy TE, Wicksteed B, Lowe WL, Layden BT. New insights into gestational glucose metabolism: Lessons learned from 21<sup>st</sup> century approaches. *Diabetes* 2015;64:327-34.
- Woolcott OO, Castillo OA, Gutierrez C, Elashoff RM, Stefanovski D, Bergman RN. Inverse association between diabetes and altitude: A cross-sectional study in the adult population of the United States. *Obesity* 2014;22:2080-90.
- Sherpa LY, Stigum H, Chongsuvivatwong V, Thelle DS, Bjertness E. Obesity in Tibetans aged 30-70 living at different altitudes under the north and south faces of Mt. Everest. *Int J Environ Res Public Health* 2010;7:1670-80.
- Voss JD, Masuoka P, Webber BJ, Scher AI, Atkinson RL. Association of elevation, urbanization and ambient temperature with obesity prevalence in the United States. *Int J Obes* 2013;37:1407-12.
- Ferrara A, Hedderon MM, Albright CL, Ehrlich SF, Quesenberry CP, Peng T, *et al.* A pregnancy and postpartum lifestyle intervention in women with gestational diabetes mellitus reduces diabetes risk factors: A feasibility randomized control trial. *Diabetes Care* 2011;34:1519-25.
- Quintanilla Rodriguez BS, Mahdy H. Gestational Diabetes. [Updated 2020 Jul 6]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2020 Jan-. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK545196>.
- Harper LM, Jauk V, Longo S, Biggio JR, Szychowski JM, Tita AT. Early gestational diabetes screening in obese women: A randomized controlled trial. *Am J Obstet Gynecol* 2020;222:495.e1-8.
- Seabra G, Saunders C, de Carvalho Padilha P, Zajdenverg L, da Silva LBG, de Souza Santos MMA. Association between maternal glucose levels during pregnancy and gestational diabetes mellitus: An analytical cross-sectional study. *Diabetol Metab Syndr* 2015;7:17.
- Woolcott OO, Ader M, Bergman RN. Glucose homeostasis during short-term and prolonged exposure to high altitudes. *Endocr Rev* 2015;36:149-73.
- Holden JE, Stone CK, Clark CM, Brown WD, Nickles RJ, Stanley C, *et al.* Enhanced cardiac metabolism of plasma glucose in high-altitude natives: Adaptation against chronic hypoxia. *J Appl Physiol* 1995;79:222-8.
- Lindgärde F, Ercilla MB, Correa LR, Ahrén B. Body adiposity, insulin, and leptin in subgroups of Peruvian Amerindians. *High Alt Med Biol* 2004;5:27-31.
- Zamudio S, Torricos T, Fik E, Oyala M, Echalar L, Pullockaran J, *et al.* Hypoglycemia and the origin of hypoxia-induced reduction in human fetal growth. *PLoS One* 2010;5:e8551.
- McClain DA, Abuelgasim KA, Nouraie M, Salomon-Andonie J, Niu X, Miasnikova, G, *et al.* Decreased serum glucose and glycosylated hemoglobin levels in patients with Chuvash polycythemia: A role for HIF in glucose metabolism. *J Mol Med* 2013;91:59-67.
- Utz B, Assarag B, Lekhal T, Damme WV, De Brouwere V. Implementation of a new program of gestational diabetes screening and management in Morocco: A qualitative exploration of health workers' perceptions. *BMC Pregnancy Childbirth* 2020;20:315.