The effect of high altitude on birth weight in the Asir Region, Saudi Arabia

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Abstract Objective: To investigate the effect of altitude on fetal birth weight.
Design: Cross sectional randomized prospective study.
Setting: Abha (3,000 meters) and Mohayel (500 meters) cities in southern Saudi Arabia.
Subjects: Healthy pregnant Saudi women and their healthy newborn living permanently at the areas of study.
Results: The mean birth weight was significantly greater at low altitude (3375 grams) than at high altitude (3207 grams) (P<0.001). The low birth weight observed at high altitude may be attributed to intrauterine hypoxia to which the fetus is subjected to. The intrauterine hypoxia appeared to be secondary to maternal hypoxia resulting from high altitude environment.

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Knowledge of normal birth weight is of paramount importance in the assessment of fetal growth and maturity. Babies born at high altitudes have been reported to have lower birth weights when compared with their counterparts born at lowland. The difference in birth weight between high and low altitude areas was attributed to various factors. It was postulated that the hemococoncentration which occurs at high altitude may lead to pregnancy induced hypertension which negatively affects birth weight. Other investigators correlated low birth weight at high altitude to placental infarcts leading to intrauterine growth retardation. However, to our knowledge, no such studies specific to the southwestern heights of the Kingdom of Saudi Arabia have been reported. The present study was, therefore, undertaken to a) determine the normal birth weight at high altitude areas of southern Saudi Arabia and to compare it with that at low altitude, b) determine any possible relationship of birth weight to maternal blood pressure and hemoglobin concentration during pregnancy and fetal hemoglobin concentration at birth. Changes in maternal and fetal hemoglobin were used as indicators for the degree of maternal and fetal hypoxia respectively.

Material and method The study was carried out at low and high altitude areas of Asir Province in the southwestern part of the Kingdom of Saudi Arabia. At high altitude (3000 meters above sea level) Abha City was selected while Mohayel City was selected at low altitude (500 meters above sea level). Environmental data on these areas are shown in Table 1. The areas involved in the study had ready access to health facilities and enjoy an adequate diet comprising mainly of meat, chicken and rice. Potable water and electricity were also available in these areas. The permanent residents in the two areas are racially homogeneous - all are Arabs and of Saudi nationality.

All the antenatal cases during 01.01.1992 to 31.12.92 who attended Abha Maternity Hospital and Mohayel Hospital were reviewed early in pregnancy in view of recruiting subjects for the study. The inclusion criteria for the study included pregnant Saudi ladies gravida two up to gravida four, known gestational age by dates and/or ultrasound and in permanent residence at the areas of study. The exclusion criteria were any disease during pregnancy, bleeding in pregnancy, poor antenatal attendance, smokers, perinatal or postnatal detection of congenital malformation.

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post term pregnancy or any discrepancy between dates and ultrasound. All the subjects who satisfied the above mentioned criteria were included (1654 at low altitude and same number at high altitude) and were followed up routinely with continuous recording of blood pressure, hemoglobin concentration and other antenatal investigations. Maternal blood pressures were measured using a mercury sphygmomanometer with the subject sitting and at rest. The diastolic pressure reading was taken at Korotoff’s Phase V. Maternal hemoglobin concentration was determined by Colter (J.T.). The mean values of blood pressure and hemoglobin concentration during the whole pregnancy were recorded and tabulated. Immediately after the delivery of any baby, the sample birth weight was taken together with a cord blood sample for determination of fetal hemoglobin concentration using Colter (J.T.).

At different stages of the study the collected data were compiled and fed into a computer. “SPSS” package has been used for standard statistical analysis including multiple regression. Student’s T-test and F-test were used where appropriate to determine statistical significance. P < 0.05 was considered statistically significant.

Results The total number of records analyzed at high and low altitude were 3417 of which 109 were excluded because they did not fulfill the criteria for inclusion in the study.

Table 2 shows the mean values and standard deviations of the means of birth weight at high and low altitude by sex. The mean birth weight was significantly greater at low altitude (3375 grams) than at high altitude (3207 grams) (P<0.001). This was true for both males and females. The mean birth weight of a lowland male baby was 3321 grams (P<0.001). In a lowland female baby the mean birth weight was 3322 grams compared with a mean birth weight of 3193 grams in a highland female baby (P<0.001). When the two sexes were compared together at the same altitude males were found to be heavier than females although the difference was less marked and insignificant at high altitude.

The mean of the average values of maternal blood pressure and hemoglobin concentration during pregnancy and the mean fetal hemoglobin concentration taken immediately after delivery are shown in Table 3. The mean maternal blood pressures and hemoglobin concentration as well as fetal haemoglobin concentration were significantly greater at high altitude than at low altitude.

Stepwise multiple regression analysis were performed to assess the impact of each of the above independent variables (maternal blood pressures and hemoglobin and fetal hemoglobin) on fetal birth weight while controlling for the remaining variables. The analyses were done collectively for high and low-landers. Regression coefficients and standardized regression coefficients are presented.
in Table 4. At both high and low altitudes maternal systolic blood pressure was the most important determinant of fetal birth weight. Three other variables were significant predictors, maternal hemoglobin concentration, fetal hemoglobin concentration and maternal diastolic blood pressure. Birth weight was lower for babies whose mothers had high blood pressure and high hemoglobin concentration during pregnancy. Birth weight was also lower for babies with high hemoglobin concentration at birth.

**Table 4** - Regression coefficients and standardized regression Coefficients for birth weight (n=3417)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Regression coefficient</th>
<th>Standardized regression coefficient</th>
<th>F-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systolic B.P.</td>
<td>-0.27</td>
<td>-0.21</td>
<td>25.62 ***</td>
</tr>
<tr>
<td>Maternal hemoglobin</td>
<td>-0.31</td>
<td>-0.16</td>
<td>17.25 ***</td>
</tr>
<tr>
<td>Fetal hemoglobin</td>
<td>-0.14</td>
<td>-0.03</td>
<td>6.73 **</td>
</tr>
<tr>
<td>Diastolic BP</td>
<td>-0.10</td>
<td>-0.02</td>
<td>4.26 *</td>
</tr>
</tbody>
</table>

*** p < 0.001  
** p < 0.01   
* p < 0.05

**Discussion** The results of this prospective study confirmed a decrease in birth weight of more than one hundred grams with the increase of about 2500 meters altitude. This result is in agreement with the published work from other areas with an altitude similar to that of Abha. The reduced birth weight reported for high altitude infants in this study may be attributed to the intrauterine hypoxia to which the fetus is subjected. The human fetus is capable of producing erythropoietin by the eleventh week of gestation and responds to intrauterine hypoxia with increase in hemoglobin concentration and hematocrit. In this study the fetal hemoglobin concentration at high altitude was found to be significantly higher than at low altitude and fetal birth weight was inversely correlated to fetal hemoglobin concentration. In a variety of obstetric conditions apart from high altitude, cord blood has an elevated hemoglobin concentration, hematocrit and erythropoietin. These conditions are known for their anoxicogenic effect on the fetus. The conditions include pre-eclampsia, smoking and cardiovascular disease.

The intrauterine hypoxia to which high altitude infants are subjected appeared to be secondary to maternal hypoxia resulting from high altitude environment. The maternal hypoxia is evident by the high maternal hemoglobin concentration at high altitude compared to low altitude. Also there is a strong and positive association between maternal and fetal hemoglobin concentration (r = 0.54, P<0.001) and a negative association between maternal hemoglobin concentration and fetal birth weight (Table 4). The negative association between maternal hemoglobin concentration and fetal birth weight is well documented in a number of studies at low altitude, a relationship which occurs in otherwise uncomplicated pregnancies.

The mechanism by which maternal hypoxia induces fetal hypoxia is not clear but appears to operate in a positive fashion with maternal arterial blood pressures. The present study showed that the maternal blood pressure was significantly higher at high altitude than at low altitude. It also showed an inverse relationship between fetal birth weight and maternal blood pressure (Table 4). The mechanism responsible for the increase in blood pressure during pregnancy at high altitude is poorly understood but an increase in the vascular resistance due to hemococoncentration and reactivity to angiotensin II level appear to precede and predict the occurrence of pregnancy induced hypertension. In this study there is a direct and strong relationship between maternal blood pressures and maternal hemoglobin concentration (r = 0.30 for SBP and r = 0.22 for DBP, P<0.001 for both) consequently, the higher blood pressures observed in pregnant women at high altitude compared to low altitude may be attributed to increased vascular resistance resulting from increased hemoglobin concentration. An effect of high altitude which elevates blood pressure during pregnancy is similar to increase in blood pressure seen in non-pregnant women permanently living in high altitude areas of Asir Province. In a large prospective study at high altitude, Naeye found that the frequency of large placental infarcts leading to intrauterine growth retardation and perinatal death is correlated positively to maternal hemoglobin. These infarcts are seen at low altitudes in cases of accidental hemorrhages which accompany maternal hypertension and cases of chronic hypoxia. Infarcted areas of the placenta have a very low perfusion rate and they negatively affect intrauterine growth.

In conclusion, this study has shown that there is a difference in birth weight between high and low altitude areas in Asir Region of Saudi Arabia. It has...
also shown that there are various factors which might have influenced this difference. Whether these factors work through the same mechanism or different mechanisms need to be investigated.

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References

ملخص:

الهدف: دراسة أثر العلو على وزن الأطفال عند الولادة.

التوصيف: دراسة استشراقية مقطعية عشوائية.

مكان الدراسة: أبها (على ارتفاع 3000 م) ومحايا (على ارتفاع 500 م) في المنطقة الجنوبية من المملكة العربية السعودية.

أفراد الدراسة: نساء سعوديات بصحبة جيدة، حوامل وأطفالهن الأصحاء حديثي الولادة، والذين يقيمون بصفة دائمة في مناطقنا الدراسة.

النتائج: تبين أن الوزن الوسطي عند الولادة أكبر كثيرًا في المناطق المنخفضة الارتفاع (572.7 جراماً) ممن في المناطق المرتفعة (207.7 جراماً) (بمعنً 0.001). ويمكن إرجاع الوزن عند الولادة في المناطق المرتفعة إلى نقص الأكسجين داخل الرحم وهذا ما يتعرض الجنين له.

وقد تبين أن نقص الأكسجين داخل الرحم ناجم عن نقص الأكسجين لدى الأم، وهذا بدوره ناجم عن ارتفاع المكان.

فتحات الكلمات: الارتفاع، وزن الوليد، نقص الأكسجين عند الام، نقص الأكسجين عند الجنين.