Birth anthropometric parameters in high and low altitude areas of Southwest Saudi Arabia

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ABSTRACT

Objectives: To study the anthropometric parameters of Southwestern Saudi newborns in Abha (a high altitude area) and Baish (a sea level area of Southwestern Saudi Arabia); to compare these parameters with those of the United States Center for Disease Control 2000 growth charts and to estimate the incidence of low birth weight (LBW) among the study population.

Methods: The study sample included all births from Abha Central Hospital (N=4300), and all births from Baish General Hospital (N=1200), Kingdom of Saudi Arabi during the period from January 2001 to January 2003. Only term births (>37-42 weeks gestation) were included. The anthropometric measurements included birthweight, crown-heel length and head circumference. The head circumference (occipitofrontal) was measured to the nearest 5 mm with an inelastic tape. Babies of LBW were identified. Low birth weight was defined as <2,500 gms at birth. Ponderal index (PI) was calculated using the formula of birthweight (in grams) x 100/length^3.

Results: Saudi newborns are lighter and shorter than those of National Center for Health Statistics newborns. The same finding was evident for head circumference. Newborns from Abha are lighter(p<0.001) and shorter (p<0.001) than from Baish. However, this difference was not significant for head circumference (p=0.53). Abha newborns showed significantly lower mean weight (2845.4 gms versus 2951.8 gms, t=58, p<0.001), and lower mean length (48.1 cm versus 48.5 cm, t=4.65, p<0.001). Low birth weight was prevalent among 24.6% of all newborns. This figure was significantly higher among newborns from Abha (25.7%) than its counterpart in Baish (20.7%), p<0.001. A strong positive correlation between the PI and birthweight (p<0.0001, R2=0.52), after adjusting for the place of birth was evident.

Conclusion: Neonates of Southwestern Saudi Arabia are significantly lighter and shorter than those of the reference population, as well as neonates in other areas of the Kingdom, with prevalent LBW especially in high altitude area, possibly due to intra-uterine growth retardation of secondary type. Ponderal index is significantly associated with birth weight even after adjusting for gender and place of birth. This might encourage the use of PI as an alternative to birth weight especially when gestational age is not available.

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Children's health is tomorrow's wealth is one of the World Health Organization's slogans of recent years. However, children's health is largely determined by factors that operate in utero, well before they are born. At birth, fetal weight is accepted as the single parameter that is directly related to the health and nutrition of the mother.[1,2] Fetal growth is influenced by a variety of factors, racial, social and economic among others, as well as specific medical conditions that may be present or that may develop during pregnancy.[3] Hence, it is not surprising that mean birth weight shows a degree of variation from country to country and from area to area within the same country.[4] So far,

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studies on Saudi birthweights have been reported from the Eastern,[5] Western,[6] Central[7] and Southern[8] provinces. The topography of Southwestern part of Saudi Arabia varies from an altitude of 3150m to sea level. The region of Assir, with a population of 1,200,000, covers more than 80,000 km² in Southwestern Saudi Arabia. Sharing its Southern border with Yemen, the area extends from the high Assir mountains almost 3200m above sea level down to the Red Sea. Abha, the capital city of the region (population 122,000), is in the Assir mountains, which is 3133 m above sea level; it has the lowest mean annual temperature of any of the Southern urban areas and has a high annual rainfall with rain falling mainly in winter and spring. Jazan, is an area located at the Red Sea, at the Southwest of Saudi Arabia, with a population of 1,400,000. Baish, the main city of Jazan, is located at the sea level, with a population of 150,000. The weather of Baish is dry and hot during summer, and rainy with relatively moderate temperatures during winter (Climate Atlas of Saudi Arabia 1988).[9]

The aim of the present study was 1) to study the anthropometric parameters of Southwestern Saudi newborns in both Abha, a high altitude area and Baish, a sea level area of Southwestern Saudi Arabia; 2) to compare these parameters with those of the United States Center for Disease Control (CDC) 2000,[10] and 3) to estimate the incidence of low birth weight (LBW) among the study population.

Methods. The study sample included all births from Abha Central Hospital, and all births from Baish General Hospital during the period from January 2001 to January 2003. A total of 5500 Saudi births were included in the present study after eliminating babies that were stillbirths, twins or those with major congenital anomalies. Only term births ($\geq$37-42 weeks gestation) were included, since many babies born outside this range are either growth retarded or structurally abnormal. The anthropometric measurements included birthweight, crown-heel length and head circumference. The birthweight of the baby was measured without clothes to the nearest 10 gms on an infant's beam balance which was calibrated daily for accuracy. Measurements were taken within a few hours of birth. An infant's board was used to determine the crown-heel length with the neonate lying flat and legs extended. The head circumference (occipitofrontal) was measured to the nearest 5 mm with an inelastic tape. Babies of LBW were identified. Low birth weight was defined as <2 500 grams at birth.[11]

A group of nurses in each hospital was allocated and trained to conduct the anthropometric measurements. Nurse batches over the period of study participated in the field data collection. Accuracy of measurements was assured by practical training sessions for nurses by repeated spot checks of normal and abnormal anthropometric values. Factors affecting apparatus reliability were reduced by having the infant's beam balance and infant board checked and calibrated. Field data collection were supervised by the authors to ensure adequate following of procedures. Daily meeting sessions were held between the nurses and field supervisors following field activities to solve problems, to check accuracy and to emphasize standardization of procedures.

Analysis of the data included mean and standard deviations of birthweight, neonate lengths and head circumferences. Comparison with CDC 2000 standards[10] was made using the Pearson Chi-squared test. A computer program placed each value in one of 4 centile bands: <10th, 10-49th, 50-89th and >90th. Using data from CDC 2000 for birthweight, neonate length and head circumference. The results were compared by x^2 analyses. Percentiles of birthweight, neonate length and head circumference were determined; 10th, 25th, 50th, 75th and 90th percentiles were calculated exactly using the frequencies procedure. Statistical tests included Students' t test and Chi square test for linear trend to compare between Abha and Baish measures. Simple factorial analysis of variance was applied to adjust for the place in testing the gender difference. Ponderal index (PI) was calculated using the formula of birthweight (in grams) x 100/length^3.[12]

Results. **Table 1** shows that Saudi newborns are lighter than those of National Center for Health Statistics (NCHS) newborns. Only 22% fell above the 50th centile, with 78% below the 10th, p<0.001. Saudi newborns were also shorter, with 77% below the 50th centile, and 30.7% below the 10th, p<0.001. The same finding was evident for head circumference, where 65% were below the 50th centile (p<0.001).

Table 2 shows that newborns from Abha (high altitude area) are lighter, shorter than those of Baish (sea level area). Those below the 10th percentile for weight constituted 42% of newborns from Abha as compared to only 33% of Baish newborns (Chi square linear trent [XLT]=16.69, p<0.001). Also approximately one third (32%) of Abha newborns are at the 10th length percentile as compared to only one-fourth (25.6%) of Baish newborns (XLT=15.105, p<0.001). However, this difference was not significant for head circumference (XLT=0.39, p=0.53).

Table 3 shows the constructed percentile values of weight, length and head circumference for Saudi newborns in both Baish and Abha. The 10th percentile for weight (1850gms), length (44cm) and head circumference (32.5cm) was the same for both newborns from Abha and Baish. The 90th

Table 1 - Centile band distribution of weight, recumbent length and head circumference for the study sample.

Centile band	Weight N	Weight (%)	Length N	Length (%)	Head circumference N	Head circumference (%)	Expected (%)
<10th	2200	(40)	1687	(30.7)	715	(13)	10
10-49th	2090	(37.9)	2543	(46.2)	2841	(51.7)	40
50-89th	495	(9.2)	1144	(20.8)	1612	(29.3)	40
≥90th	715	(12.9)	126	(2.3)	332	(6)	10
Total	**5500**	**(100)**	**5500**	**(100)**	**5500**	**(100)**	
Chi square	6326.13		3237.71		479.83		
p value	<0.001		<0.001		<0.001		

values compared with United States National Center for Health Statistics standards using Chi square analysis.

Table 2 - Centile band distribution of birth weight, length and head circumference for the study sample.

Centile band	Area	Weight	Length	Head circumference
<10th	Baish	33.3	25.6	11
	Abha	41.9	32.1	13.6
10-49th	Baish	39.8	47.7	54.3
	Abha	37.3	54.8	50.9
50-89th	Baish	15.2	25.5	31.2
	Abha	7.5	19.5	28.8
≥90th	Baish	11.8	1.3	3.5
	Abha	13.2	2.6	6.7
Chi square		16.69	15.105	0.39
p value		<0.001	<0.001	0.53

percentiles for all these measures were also the same for the 2 areas (weight=3900gms, length=51cm, head circumference=35.5cm). On the hand, the 50th percentile values of weight and length were higher for Baish newborns (3000gms and 49cm) than from Abha (2750gms and 48cm), but this difference was not shown for head circumference where it was 34cm for both groups. Abha newborns showed significantly lower mean weight (2845.4g versus 2951.8gms, t=58, p<0.001), and lower mean length (48.1cm versus 48.5cm, t=4.65, p<0.001.

Table 4 shows that male newborns were significantly heavier (t=29.988, p<0.001) and taller (t=21.375, p<0.001) than female ones. This was evident even when adjusting for the place of birth. Likewise, males had a wider head circumference than females (p<0.001).

Table 5 shows that LBW was prevalent among 24.6% of all newborns. This figure was significantly higher among newborns from Abha (25.7%) than its counterpart in Baish (20.7%), with x^2=12.58 (p<0.001). As regards to gender, a statistically significant difference was evident with LBW more prevalent among female newborns than among male ones in both Abha (35.2% versus 15.8, p<0.001) and Baish (27.8% versus 13%, p<0.001).

Table 6 shows that the mean PI is significantly higher among male newborns (p<0.001), those born at sea level (p=0.006), and those of normal birth weight (p<0.001).

Figure 1 shows the strong positive correlation between the ponderal index and birthweight (*p*<0.0001, R2= 0.52) after adjusting for the place of birth (r=0.72, R2=0.52, F=6035.93, *p*<0.0001).

Discussion. The anthropometry of newborns in the present study were less than that of the reference population. This may reflect both

Table 3 - Constructed local percentiles of birth weight, length and head circumference for the study sample.

Local percentiles	Mean ± SD	Centiles 10th	25th	50th	75th	90th
Weight						
Baish (n=1200)	2951.7667 ± 633.2239	1850.0000	2600.0000	3000.0000	3300.0000	3900.0000
Abha (n=4300)	2845.3930 ± 643.6125	1850.0000	2450.0000	2750.0000	3200.0000	3900.0000
Difference	t=5.8, *p*<0.001					
Height						
Baish (n=1200)	48.4990 ± 2.3942	44.0000	47.0000	49.0000	50.0000	51.0000
Abha (n=4300)	48.1174 ± 2.5485	44.0000	47.0000	48.0000	50.0000	51.0000
Difference	t=4.65, *p*<0.001					
Head circumference						
Baish (n=1200)	34.3125 ± 1.0630	32.5000	34.0000	34.0000	35.0000	35.5000
Abha (n=4300)	34.2691 ± 1.2363	32.5000	34.0000	34.0000	35.0000	35.5000
Difference	t=1.21, *p*=0.23					

Table 4 - Mean (SD) birth weight, length and head circumference by gender.

Growth parameters and gender	Mean ± SD	t-value (p-value)	f- value (p-value)*
Weight		29.988 (<0.001)	631.558 (<0.001)
Male (n=2693)	3115.7297 ± 667.3939		
Female (n=2807)	2631.5105 ± 517.2972		
Height		21.375 (<0.001)	326.236 (<0.001)
Male (n=2693)	48.9094 ± 2.0336		
Female (n=2807)	47.5208 ± 2.7453		
Head circumference		29.324 (<0.001)	566.087 (<0.001)
Male (n=2693)	34.7295 ± 1.1290		
Female (n=2807)	33.8459 ± 1.1045		

*adjustment for the place of birth was applied

Table 5 - Prevalence of low birth weight by gender.

Area	Male	Female	Total	Significance
Baish (sea level)	75 (13)	173 (27.8)	248 (20.7)	x^2=40.23 *p*<0.001
Abha (high altitude)	334 (15.8)	769 (35.2)	1103 (25.7)	x^2=212.14 *p*<0.001
Total	**409 (15.2)**	**942 (33.6)**	**1351 (24.6)**	

Prevalences are presented in parentheses.

Table 6 - Mean±SD of ponderal index according to some characteristics.

Characteristics	Mean ± SD	t-value	*p*-value
Gender		23.10	<0.001
Male (n=2693)	2.64 ± 0.41		
Female (n=2807)	2.43 ± 0.25		
Place		2.76	0.006
Abha (n=4300)	2.52 ± 0.37		
Baish (n=1200)	2.56 ± 0.33		
Birth weight		51.68	<0.001
Normal birth weight (n=4149)	2.65 ± 0.30		
Low birth weight (n=1351)	2.17 ± 0.26		

nutritional and ethnic variations between newborns in the present study and CDC 2000[10] data representing white American neonates. This difference was evident for both weight, length and head circumference.

Low birth weight is a global problem of great importance. Its significance is due to its association with immediate as well as late complications. It accounted for 61% of neonatal deaths in the United Arab Emirates, a country with a rapidly developing economy.[13] Its incidence varies from as low as 3% in countries such as Norway to as high as 30% in some Asian and African countries.[14] In the present study, an incidence of 24.6% was shown, which is very high if compared with figures from other parts of Saudi Arabia.[5-8,12] This high incidence of LBW might be attributed to a variety of factors such as racial, social and economic among others.

There has been much speculation concerning the growth-retarding effects of high altitude hypoxia.[15,16] Such effects were attributed to the negative energy balance and the interference with protein metabolism, leading to a significant weight loss.[17-19] Such a significant effect on weight may explain the significantly higher incidence of LBW in Abha (25.7%) than its counterpart in Baish (20.7%). This was in agreement with a study of LBW in the Taif region of Saudi Arabia, being a high altitude area approximately 2,400 meters above sea level.[20] The mean birth weights of term babies reported from the USA (Caucasian births),[21] Sweeden[22] and Australia[23] ranged from 3.4-3.6 kg. The mean birth weight in the present study (2952gms in Baish and 2845 in Abha) is lower than these figures. It is also lower than those from Central[7] (3.31kg), Western[6] (3.27kg) and Eastern[5] (3.24kg) regions of Saudi Arabia. Most of workers have considered infants as small for gestational age (SGA) when their weight gestation relationship is below the 10th percentile of their population. Some workers with birth weights below 10th percentile indicate moderate intra-uterine growth retardation (IUGR) and those below 3rd percentile (minus 2 standard deviations) signify severe growth retardation. The present study

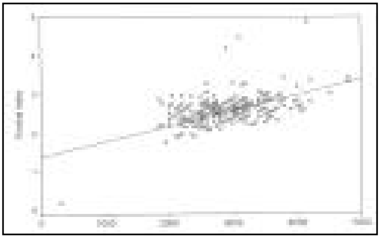

Figure 1 - The correlation between the ponderal index and birthweight.

showed that the 9th percentile weight (3.9kg) was lower than its counterparts in Saudi series.[5-8] Gender variation in birthweight has been widely reported with males being heavier than females.[7,8,21-24] This was in agreement with the findings of the present study, where male babies were significantly heavier than female neonates by 484gms ($p<0.001$) after adjustment was made for the place of birth. Also, LBW incidence was significantly higher among female neonates in the present study. This could be attributed to the difference in genetic constitution between gender. In communities where gender as a preference is evidenced, some other factors other than genetic ones could have played a role. For example, the pregnant female might have been complying with antenatal care if the baby of the future is wanted because it is a male one, more than the pregnant who was supposed to be pregnant of an unwanted female fetus. However, this explanation could not be guaranteed without further investigations. Comparing weight measurement with that of the length; the weight might reflect the intra-uterine environment, while the length might reflect the genotype. It had been reported in a previous study that 90% of the variability in height is due to heredity.[25] The mean length of term babies ($\geq$37-42 weeks), in the present study, is less than that in other areas of Saudi Arabia such as; Eastern,[5] Central,[7] Western[6] and Southern[8] provinces.

It was interesting to see that although weight and length of neonates at the high-altitude area of Abha, both were significantly lower than those at sea level, yet this was not the case for head circumference, where the mean value of head circumference in Abha (34.27cm±1.24) was not different from that in Baish (34.31cm±1.06). Fetal malnutrition should not affect the neonatal occipitofrontal circumference, since there is relative sparing of the fetal head.[12] This is in agreement with what is known as secondary or asymmetrical intra-uterine growth retardation. That is, it is a form of growth slowing or cessation occurring in a fetus with normal growth potential. This is the most common type seen in clinical practice and usually occurs in the later part of pregnancy (32 weeks) when the fetus is at the stage of maximal fat accumulation. The baby appears long and scrawling. Weight will be affected much more than length and PI is abnormal. This type of IUGR is due to impaired utero placental function or nutritional deficiency. The infants show sparing of head growth whereas weight and organ growth are more severely affected. Although, these cases have a better potential for future catch up growth. However, as abnormal pregnancies were not excluded in the present study, LBW could have also been attributed to maternal illness such as hypertension, chronic chest or heart disease. Presumably, this exclusion would have cut down on the high incidence of LBW.

In order to differentiate between the small but normally grown neonate and one which is growth retarded, the measurement of various neonatal biometric parameters is commonly used. One of the parameters is the PI, which implies that a normally grown fetus of whatever weight will have the same body proportions and that the relationship between weight and length will be constant.[26] The present study showed that PI is significantly correlated with birthweight, a finding that is in agreement with those of other studies.[12,27] It showed also that neonates of the high altitude area (with their lower birthweight and length) have significantly ($t=2.76$, $p=0.006$) lower PI (2.52±0.37) than that of those of the sea level (2.56±0.33). This finding may reflect the significantly more reduction of weight than length among neonates of the high altitude as compared to those of the sea level, with the former being more vulnerable to IUGR of the secondary type possibly due to placental insufficiency as result of the high altitude hypoxia. However, further studies are needed to compare the outcome of delivery at high and low altitude areas of Saudi Arabia in terms of morbidity and mortality

Conclusion and recommendations were as follows: (i) Neonates of Southwestern Saudi Arabia are significantly lighter and shorter than those of the reference population, as well as neonates in other areas of the Kingdom. This might be attributed to environmental and or nutritional factors. (ii) Neonates of LBW are more prevalent in Southwestern Saudi Arabia. Public health and obstetric interventions using some of the available epidemiological data may lead to a reduction in the incidence of LBW in this community and needs to be studied. (ii) Neonates of high altitude were significantly smaller than those of sea level, a finding that may be attributed to the negative impact of hypoxia that characterizes high altitude. Even, LBW was significantly more prevalent among neonates of high altitude area, possibly due to intra-uterine growth retardation of secondary type. (iv) Ponderal index is significantly associated with birth weight even after adjusting for gender and place of birth. This might encourage the use of PI as an alternative to birth weight especially when gestational age is not available or difficult to accurately calculate.

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