International Journal of Gynecology and Obstetrics (2006) **93**, 275—281

International Journal of
GYNECOLOGY
& OBSTETRICS

www.elsevier.com/locate/ijgo

SPECIAL ARTICLE

Birth weight at high altitudes in Peru

S. Hartinger [a,b], V. Tapia [b], C. Carrillo [b], L. Bejarano [b], G.F. Gonzales [a,b,*]

[a] *Department of Biological and Physiological Sciences, Faculty of Sciences and Philosophy, Universidad Peruana Cayetano Heredia, Peru*
[b] *Instituto de Investigaciones de la Altura, Universidad Peruana Cayetano Heredia, Peru*

Received 21 December 2005; received in revised form 15 February 2006; accepted 28 February 2006

KEYWORDS
High altitude;
Central Andes;
Southern Andes;
Birth weight;
Adaptation to altitude

Abstract

Objective: To determine whether birth weights are lower at high altitudes, and whether gestational age at birth and a population's length of residence mitigate the effect of high altitude. *Methods:* The birth weights of 84,173 neonates recorded in the Peruvian Perinatal Information System Database were analyzed between 1995 and 2002 for the cities of Lima (150 m), Huancayo (3280 m), Cuzco (3400 m), and Juliaca (3800 m). *Results:* Birth weight was lower at high altitude, but there was no linear relation between altitude of residence and birth weight. Mean birth weight was higher in Juliaca than in Huancayo. There were no significant differences between the 4 cities regarding birth weights of infants born between 28 and 35 weeks of gestation. However, for infants born between 36 and 42 weeks, birth weight was lower at higher altitudes. This may be due to inadequate maternal oxygenation later in pregnancy at high altitude. In the multivariate analysis, after controlling for maternal age, marital status, parity, body mass index, pre-eclampsia or hemorrhage during pregnancy, and education, as well as sex of the newborn and gestational age at birth, birth weight was lower in all cities located at a higher altitude than Lima. Yet, longer residence at high altitudes may play a protective role. Juliaca (3800 m), where the population has resided the longest, had the lowest reduction in birth weight compared with Lima (150 m); Cuzco had intermediate values; and Huancayo (3280 m), where the population has resided the shortest, had the highest reduction in birth weight. *Conclusions:* Birth weight reduction, which is independent of socioeconomic factors, occurs only in births at term and may be less severe in populations that have resided longer at high altitudes.

* Corresponding author. Av. Honorio Delgado 430, Urb. Ingenieria, Lima 31, Peru.
E-mail address: iiad@upch.edu.pe (G.F. Gonzales).

0020-7292/$ - see front matter
doi:10.1016/j.ijgo.2006.02.023

1. Introduction

Birth weight is an important marker of morbidity and mortality in newborns [1]. During the past 50 years, epidemiological studies have demonstrated that extreme childbearing ages [2,3], cigarette smoking [4], urban poverty [5], race [6], and intrauterine growth restriction (IUGR) [7] may influence birth weight. High altitude has been associated with IUGR and low birth weight in the United States [8] and the Andean countries, and several studies have demonstrated that in high altitude locations, altitude rather than economic status was associated with low birth weight [7,9–11]. In the United States, birth weight averages 351 g less in populations living between 2500 and 3100 m above sea level than in those living between 0 and 500 m [12]. Around 140 million persons worldwide reside at high altitudes (>2500 m) [10].

It has been suggested that IUGR associated to altitude varies among populations and duration of altitude exposure, with multigenerational residents demonstrating less reduction in birth weight than groups more recently arrived [13]. Data from the Himalayas have suggested that reduction in birth weight was the lowest in the longest-residing (Tibetan) groups, and higher in more recently arrived (Chinese) groups. This information was based on the consecutive deliveries of 377 Tibetan and 75 Han (Chinese) women [14]. On the other hand, a recent study from India on Tibetans living at different altitudes did not observe that Tibetans had a greater protection from IUGR than populations of more recent migration to high altitudes [15].

In Bolivia [11] and the United States [16], the reduction in birth weight at high altitudes has been largely attributable to IUGR, and much less to preterm deliveries. However, preterm delivery rates (at a gestational age <37 weeks) were higher in the Peruvian Central Andes than in Lima (150 m) [17]. This issue needed to be approached using a large database and stratifying by gestational age.

The Perinatal Information System (SIP) database, developed in different Latin America countries including Peru [18], provides an excellent tool to study low birth weight at high altitudes in Peru. The present study reports on birth weight and the variables associated to birth weight in 4 Peruvian cities located at different altitudes: Lima (150 m), Huancayo (3280 m), Cuzco (3430 m), and Juliaca (3850 m).

2. Methods

2.1. Study subjects

This study was based on the secondary analysis of data on maternal demographics, reproductive history, characteristics, and antenatal care as well as labor management, complications during pregnancy, and delivery obtained from the Peruvian Perinatal Information System (PIS) database. Criteria for exclusion were pregnancy with missing information, gestational age less than 28 weeks at birth, multiple birth, and newborn with congenital malformations. The data originated from the following public hospitals: Hospital Maria Auxiliadora and Hospital Rezola (Lima); Hospital El Carmen (Huancayo); Hospital Lorena and Hospital Regional (Cuzco); and Hospital Carlos Monge (Juliaca). As data obtained from Cuzco hospitals Lorena and Regional did not differ, they were pooled. Between 1995 and 2002, a total of 84,173 births (43,429 male and 40,744 female) were recorded for these hospitals in the PIS database. Of these births, 63,177 occurred in Lima, 12,321 in Huancayo, 3068 in Cuzco, and 5603 in Juliaca.

All of these hospitals, which are supported by the Ministry of Health, attend to people from a low socioeconomic status. In most cases, middle-class groups use Social Security hospitals or private clinics, and the upper class patronizes private clinics.

Regarding those living at high altitude, the Juliaca population, known as the Puno, is of Aymara ancestry; the Cuzco population has Quechua ancestry; and the Huancayo population derives from Huancas and then Quechua ancestry. It is considered that Aymara populations have resided longer at high altitudes than the Quechuas from Cuzco, and that the populations from Huancayo are the most recently settled. For this analysis, it was assumed that the population of Juliaca has resided the longest at high altitudes, followed by that of Cuzco, and then that of Huancayo.

Nutritional status was assessed by the mother's body mass index (BMI), which was calculated from maternal height and weight. Socioeconomic status was assessed by the mother's educational level and marital status.

Preterm infants were defined as those born before the 37th week of gestation, and term infants as those born at 37 weeks or later. Gestational age was determined from the mother's last normal menstrual period. Birth weight was recorded just after delivery. Low birth weight was defined as a birth weight less than 2500 g, and newborns at term