

Birth weight and blood pressure in first-grade elementary school students: A preliminary study

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ABSTRACT

Background Fetal programming theory reveals that low birth weight is associated with higher risks of hypertension and cardiovascular diseases in the adulthood.

Objective To study the difference in blood pressure among first-grade students of different birth weight groups.

Methods A cross-sectional study was performed. Blood pressure of 214 healthy first-grade elementary school students (102 males and 112 females) in Bunaken Subdistrict, Manado, Indonesia, was measured using a standard sphygmomanometer with appropriate cuff for arm size. Two readings were taken. Parents were asked to complete a questionnaire concerning the information on birth weight and length and confirmed by retrieving the record on a growth chart and/or a maternal-child health book. The subjects were divided into 6 groups according to their birth weight. The differences in blood pressure values between birth weight groups were examined by ANOVA.

Results Systolic blood pressures were significantly higher in the <2500 g birth weight group (100.73±9.99 mmHg vs. 93.70±8.29 mmHg) and in the 2500-<3000 g birth weight group compared to those of the 3500-<4000 g one (99.56±9.14 mmHg vs. 93.70±8.29 mmHg) with a P of 0.048 and 0.014, respectively. There was no difference between diastolic blood pressure and birth weight.

Conclusion Our study showed that the lower birth weight group tends to have a higher systolic blood pressure than that of children with normal birth weight [Pediatr Indones 2005;45:251-255].

Keywords: fetal programming, hypertension, birth weight, blood pressure

There has recently been an increasing interest in the influence of intrauterine life as a pathogenesis in the development of chronic diseases. Evidence from epidemiological studies relate to birth measurements as a proxy of fetal nutrition, with levels of cardiovascular mortality, diabetes, and risk factors, such as hypertension, dyslipidemia, glucose intolerance, hyperinsulinemia, insulin resistance, and abdominal obesity.¹⁻⁴ Birth weight is a crude measurement of fetal growth. The relationship between low birth weight and elevated blood pressure in adult life was firstly shown by Barker *et al*¹ and Law *et al*² about a decade ago and has been confirmed by an extensive series of epidemiological investigations.^{3,4} An interpretation of these findings is the level of blood pressure (and thus essential hypertension), together with other biological risk factors for cardiovascular diseases are programmed in utero through influences, which alter fetal growth.^{5,6}

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Programming is the process whereby adverse influences, which acts as critical phases of development, permanently alters the body's physiology and structure. Since the main determinant of fetal growth is the supply of nutrients, fetal adaptations towards malnutrition (lack of or imbalance in nutrients) are thought to be a major influence in programming.^{5,6}

Little is known about the association between birth weight and blood pressure in developing countries, where intra-uterine growth retardation is common. An inverse relation between birth weight and blood pressure, after adjusting for current weight, has been shown by studies in China, Chile, Guatemala, and Zimbabwe. No relation was found in Nigerian or Gambian children, or in a separate study of Jamaican children.^{7,8}

The objective of this study was to determine the difference in blood pressure among first-grade students of different birth weight groups.

Methods

A total of 7 elementary schools in Bunaken Subdistrict, Manado agreed to participate in this cross-sectional study, conducted during February 2004. Only healthy children from first-grade classes were included. Parents were asked to complete a questionnaire concerning the information on birth weight and length. The reported data on birth weight were confirmed by retrieving records on growth chart and/or maternal-child health book. The study was performed inside a quiet room located in the school area. Blood pressure was measured on 214 students (102 males and 112 females) using a standard sphygmomanometer with an appropriate cuff according to arm size. Systolic blood pressure was

determined by the onset of the tapping of Korotkoff sound (K1) and diastolic blood pressure was determined by the disappearance of Korotkoff sound (K5). For each subject, two readings were taken in 10 minutes. Current weight and height were measured.

For the purpose of descriptive analysis, the children were divided into six groups according to their birth weight, i.e. <2500 g, 2500-<3000 g, 3000-<3500 g, 3500-<4000 g, 4000-<4500 g, and 4500 g or more. The differences in blood pressure values among birth weight groups were examined by ANOVA.

Results

Two hundred and fourteen students from the first-grade classes were included in the analysis. The general characteristics and blood pressure values of the subjects are shown on **Table 1**. The birth weight of the subjects ranged from 2000 g to 4900 g. None were born with birth weight less than 2000 g. Nutritional status of all students was normal determined according to weight-for-height (WHO/NCHS).

The mean blood pressure (systolic and diastolic) for the birth weight groups are shown in **Table 2**. In

TABLE 1. GENERAL CHARACTERISTICS OF THE SUBJECTS (N=214)

Variables	Mean	± SD
Age (year)	6.51	0.62
Gender (male/female)	102 / 112	
Birth weight (gram)	3,171.28	582.30
Current weight (kg)	21.10	4.53
Current height (cm)	118.90	10.90
Systolic blood pressure (mmHg)	96.83	8.93
Diastolic blood pressure (mmHg)	62.40	8.56

TABLE 2. BLOOD PRESSURE ACCORDING TO BIRTH WEIGHT

	Birth weight groups					
	<2500 g	2500 - <3000 g	3000 - <3500 g	3500 - <4000 g	4000 - <4500 g	≥4500 g
Subjects (n)	17	53	97	37	5	5
Blood pressure						
Systolic, mmHg	100.74 ±9.99*	99.56 ±9.14 #	95.72 ±7.87	93.70 ±8.29	96.70 ±4.89	98.10 ±6.80
Diastolic, mmHg	63.74 ±6.92	63.51 ±8.48	62.08 ±8.62	60.42 ±7.45	61.40 ±7.24	66.30 ±8.93

Values are Mean ± SD or as indicated
*P=0.048 vs. group of 3500-<4000 g
P=0.014 vs. group of 3500-<4000 g.

general, the mean of both systolic and diastolic blood pressure within groups had a U-shaped curve with the lowest value in the 3500-4000 g group. Although no differences in diastolic blood pressure were observed between birth weight groups, significant differences were present for systolic blood pressure between some of the birth weight groups. Systolic blood pressures were significantly higher in the <2500 g group (100.73 ± 9.99 mmHg) and in the 2500- <3000 g birth weight group (99.56 ± 9.14 mmHg) compared to that of 3500- <4000 g (93.70 ± 8.29 mmHg; $P=0.014$) with a P of 0.048 and 0.014, respectively.

Discussion

Some limitations affected the results of the present study. Firstly, our statistical analysis was not yet adjusted to current body size. However, Loos *et al*⁹ found that in women the inverse relationship between birth weight and adult blood pressure was significant whether or not the influence of adult body mass was taken into account. Secondly, gestational age could not be retrieved for all subjects. Another weakness of our study is that data regarding birth weight were obtained mainly using the recall method.

We found a statistically significant difference in systolic blood pressure between birth weight groups. It is significantly higher in students within the low birth weight (<2500 g) group and 2500- <3000 g. Our findings support the hypothesis that low birth weight, as a marker of the intra uterine environment, is associated with an increased adult blood pressure.^{1,2,5,6}

Inverse relationship between birth weight and systolic blood pressure has been presented and replicated in many studies which now includes an excess of 80 studies.^{3,4} The fetal origins or programming hypothesis proposed by Barker *et al*¹ suggests that poor intrauterine growth resulting from suboptimal maternal nutrition leads to metabolic changes, which have adverse effects on blood pressure, serum lipid levels, and glucose tolerance in later life. The observational studies cited in support of this hypothesis reported inverse associations between birth weight and blood pressure up to 5 mmHg of systolic blood pressure per kg of birth weight.³ Subsequent studies have generally found similar but smaller effects. A systematic review of the literature published in 2000 suggests that

the size of the effect was approximately 2 mmHg different per kg of birth weight,⁴ while a more recent meta-analysis of 37 studies suggests that the true effect could be even lower, possibly less than 1 mmHg/kg.¹⁰

Most of the studies in childhood have been confined to a specific age group. This present study was performed on first grade elementary school students. The means of both systolic and diastolic blood pressure within the groups had a U-shaped curve. Law *et al*⁷ reported an inverse relation between birth weight and blood pressure in a study of 3-6 year-olds living in China, Guatemala, Chile and Sweden; except in Nigeria. But Launer *et al*¹¹ reported a U-shaped relationship between birth weight and blood pressure in the 4-year-old group. Lurbe *et al*¹² reported that birth weight was inversely related to the values and variability of ambulatory blood pressure in healthy children of age 4-18 years. Falkner *et al*¹³ were unable to demonstrate a statistically significant relation in early adolescence (age 11-14 years). Two studies in adolescents of 14-15 years age group showed a significant negative correlation between birth weight and blood pressure after adjustment for current body mass index.^{14,15}

O'Sullivan *et al*¹⁶ found that gender and age are an important influence on the relationship between birth weight and blood pressure in school children aged 6-16 years. They found that the 24-hour mean systolic blood pressure was predicted through birth weight, mostly in girls and older children (≥ 11 years). Overall, as highlighted in a recent meta-analysis most studies confirm an inverse birth weight/blood pressure relation with no differences in the pooled regression coefficients between males and females.¹⁷ The relationship is present in adolescence but attenuated compared to both pre- and post-adolescence.⁴

Although most studies confirm an inverse birth weight/blood pressure relation, the fetal programming theory still lacks complete scientific evidence in humans.^{5,6} A hypothesis proposed to explain the inverse relation of birth weight and blood pressure is that of poor nutrition in pregnancy. This hypothesis is supported by animal experiments. Several mechanisms that link to fetal growth retardation and increased blood pressure have been proposed. It has been suggested that maternal protein deprivation may lead to higher concentrations of angiotensin converting en-

zyme. The higher activities of this enzyme result from the kidney due to intrauterine growth retardation. This hypothesis is similar to that of hypertension being inversely associated with the number of nephrons, and that low birth weight babies have fewer nephrons.¹⁸ Other proposed mechanisms have included impaired vascular structure, including loss of elasticity in vessel walls, suboptimal organ development, increased concentration of insulin-like growth factor-1, and increased exposure to blood pressure raised maternal glucocorticoid hormones.^{5,6}

Epidemiological studies which link birth weight to raised blood pressure suggest that the primary prevention of adult hypertension may depend, at least partly, on intervention in pregnancy and childhood. But a full understanding of how patterns of growth in fetal life, infancy, and childhood exert their influence on blood pressure will be needed before such interventions can be rationally designed and evaluated.¹⁹

In conclusion, our study showed that first-grade school students with lower birth weight tend to have a higher systolic blood pressure than that of students with normal birth weight. Our findings support the hypothesis that low birth weight, as a marker of the intra uterine environment, is associated with an increased adult blood pressure. Further study is needed to explore the mechanisms of the birth weight-blood pressure association.

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