

Original

Birth weight and obesity risk at first grade in a cohort of Chilean children

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Abstract

The purpose of the study was to determine the association of birth weight as a risk factor for obesity at first grade in a cohort of elementary school Chilean children. Height and weight at birth and follow up measurements at first grade were analyzed from a national cohort of 119,070 new borns. Subjects were classified by anthropometric characteristics: new born weight in kilograms, Ponderal Index, (birth weight/height³ x 100), and gestational age (physical maturity) categories at birth. The study tested the hypothesis that a macrosomic newborn ($\geq 4,000$ g or > 8.8 pounds) or Large for Gestational Age, would be at higher risk to be obese at first grade. A positive relationship between birth weight $\geq 4,000$ g, (O.R. = 1.55), ($p < 0.001$), high Ponderal Index (O.R. = 1.39), ($p < 0.001$), large for gestational age (O.R. = 1.51), ($p < 0.001$), and obesity at first grade was found. Macrosomic children were more likely to be obese at first grade after controlling for the effects of confounding prenatal variables (O.R. = 1.67, ($p < 0.001$)). When weight gain between birth and first grade was $\geq 120\%$ of reference value, the obesity risk was 20 times higher ($p < 0.001$). A direct and statistically significant relationship between high birth weight and obesity at first grade in this group of Chilean children were observed. These results highlight the significance of birth weight as an important tool for healthcare providers that can be used as an indicator of obesity risk for children.

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Key words: Obesity. Children. Birth Weight. Cohort study. Chile.

PESO AL NACER Y RIESGO DE OBESIDAD EN PRIMER GRADO EN UNA COHORTE DE NIÑOS CHILENOS

Resumen

Objetivo: determinar la asociación entre el peso al nacer y el riesgo de obesidad en escolares de primer año de enseñanza básica.

Metodología: se analizó el peso y talla al nacer y las mismas variables al ingresar a la escuela en una cohorte de 119.070 recién nacidos chilenos. El peso al nacer fue categorizado: en Kg (< 2.500 g, ≥ 4.000 g), según edad gestacional (pequeño, adecuado y grande) y según el índice ponderal (peso al nacer g/ talla al nacer cm³) * 100: bajo $\leq 2,49$ normal, 2,50 to 3,16 y alto $\geq 3,17$. El estado nutricional en los escolares fue clasificado según IMC (peso/talla²) de acuerdo a la referencia del CDC. Se consideró obesidad un valor \geq percentilo 95.

Resultados: Un incremento de peso entre el nacimiento y el ingreso a la escuela $\geq 120\%$ de la referencia determinó un alto riesgo de obesidad: OR 20,5 95% IC 19,7-21,4. Se observó también una relación directa y estadísticamente significativa entre un peso al nacer ≥ 4.000 g (OR 1,55 95% IC 1,48-1,61), grande para la edad gestacional (OR 1,51 95% IC 1,45-1,57) y alto índice ponderal (OR 1,39 95% IC 1,31-1,47) con la obesidad en primer grado, controlando el efecto de variables perinatales de confusión ($p < 0,001$). El bajo peso al nacer fue un factor protector de la obesidad futura (OR 0,75 IC 0,69-0,81 $p < 0,001$).

Conclusiones: existe una relación directa entre un alto peso al nacer y el riesgo de obesidad en edad escolar. El peso al nacer puede ser una valiosa herramienta para el equipo de salud para identificar niños con mayor probabilidad de desarrollar obesidad y actuar preventivamente.

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Palabras clave: Obesidad. Peso al nacer. Cohorte. Escolar. Chile.

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Introduction

Throughout the world, among children and adolescents, overweight and obesity have become an epidemic. The World Health Organization further projects that by 2015, approximately 2.3 billion adults will be overweight and more than 700 million will be obese.¹ Globally, in 2010 the number of overweight and obese children under the age of five, has been estimated to be over 42 million with about 35 million living in developing countries. Once considered a problem only in high-income countries, overweight and obesity are now dramatically on the rise in low- and middle-income countries, particularly in urban settings.²⁻⁶ In Chile, there is an elevated and increasing prevalence of obesity affecting about 10% of children under six years of age and increasing to 20% by the time they start elementary school. Overall, overweight and obesity affects over half of Chile's adult population.⁷⁻⁹

Biological and genetic factors coupled with environmental and socio-economic conditions have been found to determine obesity from early life to adulthood.¹⁰⁻¹¹ There is solid scientific evidence of the inverse association of low birth weight and cardiovascular disease in adulthood.¹²⁻¹⁵ Existing evidence points out that high birth weight in addition to rapid weight gain at an early age, is a risk factor for childhood obesity at a later age.¹⁶ However, there is insufficient evidence of the relationship between birth weight and later obesity.

The purpose of the study was to determine the association of birth weight with the risk of obesity at first grade in a cohort of elementary school Chilean children.

Methods and procedures

Data from a national cohort of 119,070 new born and subsequent measurements at first grade of school were analyzed. Anthropometric measurements and socio-demographic information were obtained from the National Birth Registry and from the nationwide school based Nutritional Assistance Program or Junta Nacional de Auxilio Escolar y Becas (JUNAEB), at birth and at first grade, respectively. About 77% of Chilean children attend public school,¹⁷ and it was assumed that this group would be representative of the Chilean population within this age group. Anthropometric and demographic data were collected at each elementary school by its personnel and submitted to the JUNAEB on a yearly basis. To link the birth registry and the JUNAEB databases, the universal national unique identifier, which is routinely included in data collection forms was used. After assessing all cases, 93% of cases showed identification correspondence. All those cases were included in the analysis.

The study tested the hypothesis that a macrosomic newborn ($\geq 4,000$ g or > 8.8 pounds), or with high Pon-

deral Index or Large for Gestational Age (LGA), would be at higher risk to be obese at first grade. Birth weight, the main explanatory variable, was classified as follows: Low Birth Weight (LBW) $< 2,500$ g; Insufficient Birth Weight (IBW) 2,500 to 2,999 g; Normal Birth Weight (NBW) 3,000 to 3,999 g; Macrosomic (M) $\geq 4,000$ grams or 8.8 pounds. Birth weight was also classified by Ponderal Index (PI), calculated as (birth weight g/birth length cm^3) $\times 100$ and categorized as: Low Ponderal Index (LPI) ≤ 2.49 ; Normal Ponderal Index (NPI) 2.50 to 3.16; High Ponderal Index (HPI) ≥ 3.17 . Additionally, new born were classified by birth weight in relation to gestational age as: Small for Gestational Age (SGA) $< 10^{\text{th}}$ percentile; Adequate for Gestational Age (AGA) 10^{th} to 90^{th} percentile; Large for Gestational Age (LGA) $> 90^{\text{th}}$ percentile, following Chilean intrauterine growth references.¹⁸ Gestational Age (GA) was classified as: pre-term < 37 weeks of gestation; full-term between 37 and 41 weeks of gestation and post-term ≥ 42 weeks.

First grade school children Body Mass Index (BMI) was calculated by using (weight/height²) and classified in relation to U.S. Centers for Disease Control's (CDC) BMI tables for age and gender:¹⁹ underweight (less than the 5th percentile); normal weight (5th percentile to less than the 85th percentile); overweight (85th to less than the 95th percentile); obese (equal to or greater than the 95th percentile).

Additional variables collected at birth included: urban or rural residency, and mother's age, marital status and school attainment. The continuous variables, standard deviations and means were examined and tests of hypothesis for group comparisons were carried out. Frequency distributions for categorical variables were evaluated, and chi square (χ^2) was used to analyze group differences. Odds Ratios (O.R) and Confidence Interval (CI) were performed to evaluate risk and association between obesity and risk factors. Gender was used as control variable for the analysis. The relationship between birth weight and obesity at first grade was assessed using a multiple logistic regression model adjusted for gender, height at birth, mother's age and her school attainment at delivery. The model was used to evaluate the association between the explanatory variable (birth weight) and the outcome variable (obesity). STATA 10.1 was used for all statistical analyses.²⁰ Statistical significance was set at $p < 0.001$.

Results

Of the 119,070 children included in the sample, slightly over one half were female (51.9%). The mean age was 6.3 ± 0.3 years for both, girls and boys. The mother's sociodemographic characteristics indicated that at the time of delivering the child, the majority (89%) were over 18 years of age, with a mean age of 26 ± 6 years; almost two thirds (64%) were married. Less than one percent had no schooling; 40% had completed

Table I
Anthropometric characteristics of Chilean children cohort from new born and first grade

	Male	Female	Total
	X ± SD n = 57,254	X ± SD n = 61,816	X ± SD n = 119,070
<i>New Born</i>			
Weight (g)	3,367 ± 495	3,258 ± 468	3,306 ± 489
Height (cm)	49.9 ± 2.2	49.2 ± 2.2	49.5 ± 2.2
Gestational weeks	39.1 ± 1.5	39.0 ± 1.5	39.1 ± 1.5
Ponderal Index	2.70 ± 0.28	2.73 ± 0.29	2.71 ± 0.32
<i>First Grade</i>			
Age (years)	6.1 ± 0.3	6.1 ± 0.3	6.1 ± 0.3
Weight (kg)	23.1 ± 4	22.7 ± 4	22.9 ± 4
Height (cm)	117.6 ± 5.4	116.8 ± 5.4	117.0 ± 5
BMI	16.7 ± 2.3	16.5 ± 2.4	16.6 ± 2.3
Weight gain: birth to first grade (kg)	19.8 ± 3.9	19.4 ± 4	19.6 ± 3.9
Height gain: birth to first grade (cm)	67.7 ± 5.3	67.6 ± 5.3	67.6 ± 5.3

elementary school (6th grade), and nearly 60% had high school or more (data not shown).

Table I shows the cohort anthropometric characteristics at birth, which were all within normal values. The cohort mean height and weight at first grade were also within normal range, but the mean BMI was near the 75th percentile in both genders, which was about one point over the reference value.

At first grade, close to 35% of children in the cohort were overweight (14.6%) or obese (20%). Males presented

Table II
Nutritional status distribution by BMI and gender within first grade

Nutritional status	First Grade		
	Male %	Female %	Total %
Low Weight	6.9	7.9	7.4
Normal	57.3	59.5	58.5
Overweight	19.8	19.3	20.0
Obese	16.0*	13.3	14.6
Total	100.0	100.0	100.0

*Association Test χ^2 p < 0.001.

higher obesity rates (16%) than females (13.3%) (p < 0.001). The overall low weight for age was 7.4% (table II).

A positive direct relationship between high birth weight and obesity at first grade was observed (table III). The prevalence of obesity was 11.1% among children weighing $\leq 2,500$ g; in contrast, it was almost twice among macrosomic children (21.7%). The same trend was observed among those with high Ponderal Index (20%) and those large for gestational age at birth (21.3%) (table III). A lower prevalence of obesity was observed among children who were in the lower birth weight, Ponderal Index, and gestational age categories at birth (p < 0.001, table III). In addition, the prevalence of low weight at first grade was higher among those children with low Ponderal Index, and small for gestational age (p < 0.001, table III).

As seen in table IV, low birth weight was associated with a lower likelihood to develop obesity (OR = 0.75),

Table III
BMI distribution at first grade in relation to new born characteristics

	Nutritional status at first grade				Total %	*p
	Low weight %	Normal %	Overweight %	Obese %		
<i>New Born Weight</i>						
$\leq 2,500$	11.9	62.4	14.6	11.1	100.0	p < 0.001
2,500-3,999	7.5	59.0	19.4	14.2	100.0	p < 0.001
$\geq 4,000$	4.3	49.9	24.1	21.7	100.0	p < 0.001
<i>Ponderal Index</i>						
Low	10.3	61.2	16.7	11.8	100.0	p < 0.001
Normal	6.9	58.1	20.1	15.0	100.0	p < 0.001
High	4.0	53.2	22.9	20.0	100.0	p < 0.001
<i>Weight /gestacional age</i>						
SGA	11.7	62.4	15.2	10.8	100.0	p < 0.001
AGA	7.0	58.5	20.0	14.6	100.0	p < 0.001
LGA	4.5	51.1	23.1	21.3	100.0	p < 0.001

*Association Test χ^2 .

Table IV
Odds ratio, attributable risk and explanatory variables of obesity at first grade

Risk factor	OR	CI	p	AR*	CI	p
Birth weight < 2.500 g	0.75	0.69-0.81	p < 0.001	0.24	0.18-0.30	p < 0.001
Birth weight ≥ 4.000 g	1.55	1.48-1.61	p < 0.001	0.35	0.32-0.38	p < 0.001
High Ponderal index	1.39	1.31-1.47	p < 0.001	0.28	0.23-0.32	p < 0.001
Large for gestational age	1.51	1.45-1.57	p < 0.001	0.34	0.31-0.36	p < 0.001
Pre term new born	0.87	0.80-0.93	p < 0.001	0.13	0.06-0.19	p < 0.001
Weight Gain ≥ 120% between birth and first grade	20.5	19.7-21.4	p < 0.001	0.95	0.94-0.95	p < 0.001

OR = Odd Ratio; CI = Confidence Interval; AR = Attributable Risk.

(p < 0.001). A positive relationship was found between high Ponderal Index, birth weight ≥ 4,000 g, large for gestational age at birth and obesity at first grade. Among those with high Ponderal Index at birth, the risk of obesity was almost 40% higher (OR = 1.39), p (< 0.001), and those in the large for gestational age category had 51% higher risk of being obese at first grade (p < 0.001). When weight gain between birth and first grade was ≥ 120% of reference value, the obesity risk was 20 times higher (p < 0.001) (table IV). The additional analyses were performed to test the main explanatory variable, using different classifications of birth weight, showed no statistically significant differences. The attributable risk is also presented in table IV, showing all birth weight categories being statistically significant (p < 0.001). Further analyses of other categories of birth weight did not show an inverse relationship between birth weight and obesity at a later age.

Table V shows the multiple logistic regression model, adjusted for prenatal characteristics such as gender, mother's education, shows a 67% higher risk of developing obesity in first grade for macrosomic new born (p < 0.001). Being female and having a mother with elementary school education provided a protective factor for obesity with ORs of 0.82 and 0.77 respectively, (p < 0.001).

Table V
Relationship of prenatal characteristics and obesity at first grade using adjusted multiple logistic regression model

Variables	Adjusted OR and adjusted Confidence interval	
	OR	95% CI
Macrosomic	1.67*	1.58-1.76
Female	0.82*	0.80-0.85
Elementary maternal education	0.77*	0.75-0.80

*p < 0.001.

Discussion

The results of this study showed a positive relationship between different children's birth weight indicators and obesity at first grade. Macrosomic Chilean infants were more likely to be obese by first grade (OR = 1.55) and after controlling for the effects of confounding pre natal variables with an OR = 1.67, both were statistically significant. These findings corroborate the direct and statistically significant relationship between high birth weight and obesity at first grade in this group of children. These results are consistent with the findings reported recently by Mardones, et al. (2008), who found that higher ORs relating Chilean macrosomic children and obesity at school²¹ and also consistent with others international studies.²²⁻²⁴ Regarding the attributable risk, it can be concluded that overweight or obesity could have been prevented in about one third of school age children with preventive interventions that target those children identified as macrosomic, or high ponderal index, or large for gestational age at birth.

Maternal obesity before conception or during gestation has a strong association with fetal macrosomia,^{25,26} and also with the risk of the child developing obesity after birth. This association can be explained by genetic factors, fetal programation or environmental conditions which continue affecting the children after birth. The current study can not determine the strength of these factors, but is very likely that the parents' lifestyles can strongly affect the children's nutritional status.

A systematic review of the association of birth weight or rapid growth has indicated that height and weight, as well as rapid growth, increase the likelihood to become obese.²² In boys and girls, birth weight, maternal weight and father's occupation, as well as breastfeeding has been found to be significantly associated with BMI through adulthood in British children.²⁷ In 6 to 13 year old children, as birth weight increased, the overweight risk consistently increased.²⁸

Low birth weight has been suggested as a protective factor for overweight and obesity among German children.²⁹ Gestational age, normal and high birth weight and birth length for gestational age were found to be risk factors for overweight and obesity in Swedish youth.³⁰ Similarly, among Chilean children in this study, birth weight, gestational age and Ponderal Index were identified as risk factors for obesity in childhood.³¹

At first grade the anthropometric characteristics of the cohort were within the normal values, although BMI was about one unit over the expected value for their age range. In addition, weight gain between birth and first grade was higher than the expected normal gain (19.6 kg vs. 17.3 kg), with a normal height increase within the same period, which could explain the higher BMI. High birth weight, being a new born large for gestational age, and having high Ponderal Index, were the main explanatory variables and it indicates the effects of in utero or pre birth factors. These findings suggested that children that were under unfavorable nutritional conditions during gestation and at birth may still present those conditions at the time they reach school age. In addition, being obese at first grade can also be influenced by other post natal variables and exposure to environmental factors after birth and throughout the early years. Factors such as unhealthy eating habits and a sedentary lifestyle, very common among children, may have had a negative impact in the child's weight as suggested by the literature.^{32,33}

The main strength of this study relates to the analyses of longitudinal data, from birth to 6 or 7 years of age, for over one half of Chilean children born within that window of time who were included in this cohort and are representative of the Chilean population within that age. Therefore the findings of the study and the recommendations can be applied to all children in this age group within the country. Nevertheless, the use of secondary data, the lack of information on additional familial characteristics, such as eating and physical activity habits, is limitations of the study findings. Finally, not having the data on the growth patterns in the child's first and second year, poses another limitation, because early age growth patterns have been associated with overweight and obesity in the following years.

In summary, the study findings provides valuable information that can assist and guide the formulation of national and international public health policies that aim to protect the health of vulnerable groups from birth to early age and throughout school age by preventing obesity and the consequential health problems from childhood to adulthood.

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