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Birthweight and its association with cardiometabolic risk parameters in rural Maya children from Yucatan, Mexico

Julio Lara-Riegos[a], Hugo Azcorra[b], Juan Carlos Salazar-Rendón[c], Víctor Arana-Argáez[d], María Teresa Castillo-Burguete[e] and Nina Mendez-Dominguez[f]

[a]Laboratorio de Bioquímica y Genética Molecular, Facultad de Química de la Universidad Autónoma de Yucatán, Mérida, México; [b]Centro de Investigaciones Silvio Zavala, Universidad Modelo, Mérida, México; [c]Dirección de Nutrición y Enfermedades Crónicas, Secretaría de Salud, Mérida, México; [d]Laboratorio de Farmacología, Facultad de Química de la Universidad Autónoma de Yucatán, Mérida, México; [e]Centro de Investigación y de Estudios Avanzados del Instituto Politécnico Nacional, Mérida, México; [f]Hospital Regional de Alta Especialidad de la Península de Yucatán, Mérida, México

ABSTRACT

Background: Knowledge about the influence of early developmental factors on cardiometabolic health in the Maya is limited.

Aim: To analyse the relationship between birthweight (BW) and cardiometabolic parameters in a sample of rural Maya children from Yucatan, Mexico.

Subjects and methods: We took anthropometric measurements and obtained data on BW and fasting blood samples in a sample of 75 children aged 5–14 years. Dependent variables were: fat mass index (FMI), body mass index (BMI), glucose (G), triglycerides (TG), total cholesterol (TC), high-density lipoprotein cholesterol (HDL), low-density lipoprotein cholesterol (LDL), LDL/HDL and TC/HDL ratios and metabolic index (TGxG/HDL^2). Outcomes were transformed to $y = 100$ log(e)x and the resulting estimates are interpreted as symmetrical percentage differences. The main independent variable was BW z-score. Multiple linear regression analyses were used to assess the relationship between BW and outcomes.

Results: An increase of one standard deviation in BW predicted 6.6% (95% CI [−11.6, −1.6]) decrease in HDL and 11% (95% CI [3.7, 18.4]), 7.8% (95% CI [2.3, 13.2]) and 19.6% (95% CI [3.1, 36]) increases in LDL/HDL, TC/HDL and metabolic index, respectively.

Conclusion: Higher birthweights were associated with adverse levels of biochemical parameters in this sample of rural Maya children.

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Birthweight; cardiometabolic health; Maya; Yucatan; Mexico

Introduction

Indigenous populations from middle- and low-income countries have historically experienced adverse living conditions as a result of several mechanisms of political control and discrimination. Such conditions often impact the phenotype and metabolism of individuals in an intergenerational way through several manners, including alterations in organ structure and function during prenatal development and epigenetic processes (e.g. Godfrey and Hanson 2009; Kuzawa and Gravlee 2016). Currently, indigenous groups, particularly those residing in rural communities, experience changes in lifestyle and wellbeing related with environmental degradation, migration processes and globalisation, including economic activities (Orden and Oyhenart 2006; Benefice et al. 2007; Zonta et al. 2011; Bogin et al. 2020). Overall, the combination of chronic poverty and current demographic and sociocultural transitions experienced by minority indigenous groups may explain the presence of cardiometabolic diseases with predominance of obesity, type 2 diabetes (T2D), hypertension, and dyslipidemias.

The Maya are the largest ethnic group in America and are nowadays distributed across Mexico, Guatemala, El Salvador, Belize and Honduras. A significant number of Maya people reside in the US as a result of a migration process that has increased in the past two decades. The Yucatan Peninsula, in Mexico, is the home of a great number of Maya people; according to census data, in 2020 there were more than 500,000 Mayan speakers living in the state of Yucatan (INEGI 2021). The Maya from Yucatan residing in the more than 2,000 rural communities have experienced, in recent decades, changes in livelihoods through a gradual integration into market economies as a result of government regional and national policies and globalisation processes.

Studies conducted in Yucatan have shown the high prevalence of excess body weight (overweight and obesity), T2D,

CONTACT Hugo Azcorra hugoazpe@hotmail.com Centro de Investigaciones Silvio Zavala, Universidad Modelo; Carretera a Cholul 200 metros periférico norte, C.P. 97310, Mérida, Yucatán, México

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insulin resistance and dyslipidemias among the Maya (Lara-Riegos et al. 2015; Loria et al. 2020). In fact, the Maya have the highest levels of T2D and obesity compared with other Mexican ethnic groups (Lara-Riegos et al. 2015). Some studies have suggested that the Amerindian genetic component, derived from natural selection processes, plays an important role in the susceptibility to developing metabolic diseases related to alterations in lipid metabolism and insulin resistance (Qu et al. 2012; Ko et al. 2014). The proportion of the Amerindian genetic component varies in Mexico, being higher in the southeast of Mexico, where the Maya population lives mainly (Barquera et al. 2020; Lara-Riegos et al. 2020). In addition, the presence of polymorphisms in apolipoproteins related to the levels of high-density lipoprotein cholesterol, total cholesterol and triglycerides among the Maya has been documented (Ferrell et al. 1990; Ahn et al. 1991). Some of these lipid parameters have served to produce several indices that have been related to atherogenic risk, such as metabolic index, an indirect measure of insulin resistance (Roitberg et al. 2015; Lara-Riegos et al. 2018).

However, little is known about the influence of early developmental factors on cardiometabolic health in the Maya. According to the Developmental Origins of Health and Diseases (DOHaD) perspective, conditions experienced by individuals during intrauterine development may shape later phenotype and metabolism through adjustments in the structure and function of organs that are relevant in the use of energy and nutrients. Under this framework, growth deficit during gestation may increase postnatal morbidity risk, particularly of chronic degenerative diseases (Godfrey and Hanson 2009). Recent increases in maternal obesity, even in populations that have experienced chronically disadvantaged socioeconomic conditions, complicate the relationship between intrauterine growth and phenotype and metabolism during postnatal life. Several studies have investigated the relationship between birthweight, a crude measure of intrauterine growth, and cardiometabolic parameters including glucose, insulin, total cholesterol, triglycerides, HDL and LDL in children (see reviews by Newsome et al. 2003; Laurén et al. 2003). Consistent with the DOHaD perspective, some studies have found inverse relationships between birthweight and fasting plasma glucose, insulin concentrations and insulin resistance (Hofman et al. 1997; Whincup et al. 1997; Bavdekar et al. 1999; Harder et al. 2001; Li et al. 2001) and a smaller number of studies have shown U-shaped associations (Nordman et al. 2020). Increased weight gain during postnatal growth may mediate the relationships between birthweight and risk for glucose and insulin abnormalities (Wilkin et al. 2002; Ong and Dunger 2004). The relationship between birthweight and blood lipid concentrations in children is not conclusive. Interestingly, some studies show that at some point high birthweight is associated with adverse blood lipid profiles (Laurén et al. 2003). Infants born to Maya mothers have birthweights lower than those born to non-Maya women (Azcorra et al. 2016) as a result of short maternal stature (Azcorra and Mendez 2018) and adverse socioeconomic conditions (Aldrete-Cortez et al. 2022). However, as far as we know, the influence of birthweight on the cardiometabolic health of the Maya from Yucatan has not been investigated.

This study derives from a research project that aimed to analyse the changes in anthropometric characteristics during the last 3.5 decades (1986–2022) in children from Dzeal, a rural Maya community in Yucatan, Mexico, and evaluate the influence of perinatal and familial factors on body composition and metabolic health of the studied children. The data used in this study correspond to the cross-sectional third-wave survey conducted during 2022 in which additionally to anthropometric measurements, we obtained perinatal data and blood samples in children. The aim of this study was to analyse the relationship between birthweight and cardiometabolic risk parameters in children from Dzeal, Yucatan.

Subjects and methods

Study location

Dzeal is a rural predominantly Maya community located in the southeast of Yucatan. By 2020, the community was composed of 457 people distributed in 107 families; 80% of people aged three years and older were Mayan speakers and 94% of children in this study had paternal and maternal Maya surnames. Dzeal is one of a significant number of communities in Yucatan that live with a high level of material poverty (INEGI 2021). Until three decades ago, the inhabitants of the community depended on the self-subsistence agricultural system called milpa, a seasonal system in which maize plays a central role in the religious and philosophical belief system of the Maya (Fernández del Valle Faneuf 2011). Due to its proximity to touristic Chichen Itza, Cancun and the Riviera Maya, the inhabitants of Dzeal have been gradually incorporated into the tourism-related labour dynamics over the last 3–4 decades. By 2022, around 64% of the men worked outside of the community, mainly as construction workers, but also as maintenance workers in hotels and restaurants in Kaua (the county head village) and Quintana Roo, and Mérida (Azcorra et al. 2023). More recently, women have begun to participate in economic activities. In 2022, 17% of women were salaried workers working as kitchen and cleaning staff in Chichen Itza and Kaua, and a minor proportion were entrepreneurs in Dzeal. The incorporation of men and women into salaried work in the region, together with a relative improvement in families' material living conditions, have contributed to a reduction in the prevalence of chronic malnutrition (low height-for-age) in children but a sustained increase in excess body weight during the last decades (Azcorra et al. 2023).

Sample

The eligible population for this cross-sectional study conducted between October 2022 and February 2023 was 118 children aged 3–14 years. 24 mothers did not accept that their children give blood samples; the majority ($n = 20$) of them corresponded to children aged 3 and 4 years. Another 19 cases did not have their birth certificates so it was not possible to obtain their birthweights and gestational ages. The final sample consisted of 75 children (39 girls) aged 5–14 years with complete data on birthweight, weeks of gestation, anthropometric measurements and socioeconomic characteristics of the family and who agreed to participate in the blood tests. Children included in the study were 1.8 years (mean= 10.3 years vs mean= 8.5 years) older than children excluded by incomplete data, however they were similar in z-score values of height, BMI and fat mass index.

Data collection

Birthweight, anthropometric and body composition data

Data on children's birthweight and week of gestation were obtained from birth certificates. Children's birthweights were transformed to gestational week and sex-specific z-scores using the INTERGROWTH-21st standards for newborn size (Villar et al. 2014). Children's height (cm), weight (kg), and triceps skinfold (mm) were measured by two nutritionists in the morning at the schools, following standardised methods (Lohman et al. 1988). We estimate body fat mass (kg) using the anthropometric equation developed by Ramírez et al. (2012). The equation was developed in a sample of 336 Mexican school children (5–14 years of age) of different geographical regions and ethnicity based on deuterium oxide dilution technique. Forty-three percent of children included in the analysis belong to six major indigenous groups, including the Maya from Yucatan. Fat mass (FM) was then converted to fat mass index (FMI = FM [kg]/height [m]^2); we selected FMI rather than percentage or absolute mass because FMI is adjusted for variation in size.

The anthropometric equation used to estimate fat mass was:

$$\begin{aligned}\mathrm{FM}(\mathrm{kg}) = &-1.067\times \mathrm{sex}(\mathrm{male}=1, \mathrm{female}=0)\\ &+0.458\times \mathrm{Triceps\ skinfold}(\mathrm{mm})+0.263\times \mathrm{Weight}(\mathrm{kg})-5.407\end{aligned}$$

Z-scores and percentiles by age and sex, for height (HAZ) and body mass index (BMIZ) were calculated using the reference values published by Frisancho (2008) to describe growth status of children. Low height-for-age was assessed based on a HAZ below the 5th percentile, and low and high BMI-for-age were determined when the BMIZ was below the 5th percentile and above the 85th percentile, respectively.

Biochemical parameters

Blood samples were taken after fasting for 10 to 12 h and were processed by venous puncture the same day in the Clinical Analysis Laboratory of the Community Service of the Faculty of Chemistry of the Autonomous University of Yucatán. Biochemical determinations of glucose (G), total cholesterol (TC), high-density lipoprotein cholesterol (HDL), low-density lipoprotein cholesterol (LDL) and triglycerides (TG), were performed according to the manufacturer's instructions (Roche) with standardised methods in a Cobas Integra® 400 Plus (Roche) analyser. The analytical quality of the process was monitored by an internal quality control system and participation in an external quality assurance program. We calculated the metabolic index using the formula (TGxG/HDL^2) proposed by Roitberg et al. (2015) and used it as a proxy measure for insulin resistance. Cardiovascular risk assessment was performed through the TC/HDL and LDL/HDL indices (Manninen et al. 1992; Gotto et al. 2000). Higher values of metabolic index, TC/HDL and LDL/HDL indicate greater risk for health.

Sociodemographic data

We applied a sociodemographic questionnaire to children's mothers to obtain information on living conditions of families. In this study, we focus on the crowding index in the household (total number of people living permanently in the house divided by the number of rooms used to sleep) and used this as an indicator of the socioeconomic conditions of the family. Crowding in the household provides information about the capacity of parents to invest in the conditions experienced by family members.

Statistical analysis

Entry, cleaning, and analysis of data were done using Stata/IC 11.1 for Windows statistics package (StataCorp LP, 2010). Student's independent t tests were used to compare birthweight, anthropometric, body composition and biochemical characteristics between boys and girls. The association between birthweight and cardiometabolic risk parameters was analysed through multiple linear regression analyses. The main independent variable was children's birthweight (z-scores) and the outcomes were: BMI, FMI, G, TC, TG, HDL, LDL, LDL/HDL ratio, TC/HDL ratio and metabolic index. Outcomes were skewed so were transformed to $y = 100\ \log(e)x$ and the resulting estimates are interpreted as symmetrical percentage differences (Cole 2000). All models were adjusted for children's age, sex and crowding index in the family; age and crowding index were treated as continuous variables. Some studies adjust their analyses for individuals' current size (e.g. weight, BMI) or body composition (e.g. fat mass, body fat percentage). However, current size may act as an intermediate rather a confounding factor, which complicates the interpretation of results (Groenwold et al. 2021). Exploratory analyses of our data showed that the inclusion of children's weight, BMI or body fat percentage did not modify the magnitude and direction of associations between children's birthweight and their blood metabolic levels. Therefore, we present the results of models without adjusting for these factors. Models satisfied assumptions of normality of residuals, non-collinearity between predictors and homoscedasticity.

Ethical concerns

The Research Ethics Committee of the Autonomous University of Yucatan approved this research (CEI-06-2022). During school meetings, mothers were informed of the study and invited to sign a form to indicate their consent. Before measurements, children were also informed and asked to provide their assent verbally if they were willing to participate.

Results

The mean birthweight in the overall sample was 2969 g and the average z-score value was −0.45 standard deviations (Table 1). Compared with international birthweight standards, 18% of children were below 10th percentile (small-for-gestational age). The mean value for HAZ was −1.1 standard deviations and 30% of children met the criteria for low height-for-age; the average value of BMIZ was 0.5 standard deviations and 30% of children were classified as high BMI-for age (excess body weight). Girls showed greater mean values of fat mass (difference = 3.3 kg, 95% CI [1.35, 6.03]) and FMI (difference = 1.5 kg/m^2, 95% CI [0.20, 2.6]) than boys (Table 1). Although differences in height, weight, triceps skinfold and BMI by sex did not reach conventional significance levels ($p < 0.05$), girls showed greater mean values than boys, which could be due to the fact that they are, on average, one year older. Mean values of biochemical parameters were more similar between sexes.

The multiple linear regression analyses showed that birthweight was inversely associated with HDL and positively associated with LDL/HDL and TC/HDL ratios and the metabolic index (Table 2). Specifically, an increase of one standard deviation in birthweight predicted 6.6% (95% CI [−11.6, −1.6]) decrease in HDL and 11% (95% CI [3.7, 18.4]), 7.8% (95% CI [2.3, 13.2]) and 19.6% (95% CI [3.1, 36]) increases in LDL/HDL ratio, TC/HDL ratio and metabolic index, respectively. The relationships between birthweight and HDL, LDL/HDL, TC/HDL and metabolic index into the models are shown in Figure 1. Associations between children's birthweight and BMI (2.5%, 95% CI [−0.6, 5.6]), FMI (1.5%, 95% CI [−9.5, 12.6]), G (−1.1%, 95% CI [−2.7, 0.6]), TG (7.6%, 95% CI [−2.9, 18.1]), LDL (4.5%, 95% CI [−0.8, 9.7]) and TC (1.2%, 95% CI [−2.9, 5.2]) were weaker and could not be confidently distinguished from the null hypothesis. However, except for glucose, associations were in the same adverse direction as the more convincing for HDL, LDL/HDL, TC/HDL and metabolic index.

Models showed that crowding index was associated with BMI (−1.8%, 95 CI [−3.4, −0.5]), FMI (−8.5%, 95 CI [−14.5, −2.5]), HDL (3.8%, 95 CI [1.1, 6.4]), LDL/HDL (−6.2%, 95 CI [−10.1, −2.2]), TC/HDL (−4.4%, 95 CI [−7.4, −1.5]) ratios and metabolic index (−11.7%, 95 CI [−20.5, −2.9]). In other words, greater crowding in the household was associated with lower values of adiposity and beneficial levels of cardiometabolic parameters in children. When models were performed without crowding index, the direction and magnitude of association between birthweight and outcomes did not change substantially (See models without crowding index in supplementary material).

Table 1. Descriptive statistics of anthropometric, body composition and cardiometabolic characteristics of participants.

Characteristics	All sample ($n = 75$) Mean (SD)	Boys ($n = 36$) Mean (SD)	Girls ($n = 39$) Mean (SD)	*P*-value
Age (years)	10.3 (2.5)	9.8 (2.5)	10.8 (2.4)	0.114
Birthweight (g)	2969 (450)	2951 (501)	2984 (505)	0.755
Gestational age (weeks)	38.9 (1.6)	38.8 (1.8)	38.9 (1.5)	0.908
Birthweight (z-score)	−0.45 (0.96)	−0.62 (0.94)	−0.30 (0.93)	0.153
Height (cm)	133.0 (14.7)	130.5 (15.9)	135.3 (14.2)	0.166
Height-for-age z-scores	−1.1 (0.9)	−1.1 (0.9)	−1.2 (0.9)	0.727
Weight (kg)	35.3 (13.4)	33.4 (12.6)	37.1 (14.1)	0.235
Body mass index (kg/m^2)	19.3 (3.8)	18.9 (3.2)	19.6 (3.3)	0.445
Body mass index (z-score)	0.5 (0.9)	0.6 (0.9)	0.4 (0.8)	0.281
Triceps skinfold (mm)	15.1 (6.7)	13.7 (6.5)	16.3 (6.6)	0.100
Body composition – Anthropometric equation				
Fat-free mass (kg)	25.3 (8.1)	24.9 (8.1)	25.6 (8.2)	0.727
Fat mass (kg)	10.4 (6.2)	8.6 (5.6)	11.9 (6.3)	0.019
Fat mass index (kg/m^2)	5.5 (2.6)	4.7 (2.6)	6.2 (2.6)	0.015
Biochemical parameters				
Glucose (mg/dL)	89.8 (6.4)	89.3 (6.2)	90.2 (6.5)	0.555
Total cholesterol (mg/dL)	131.6 (20.4)	131.7 (21.6)	131.5 (19.5)	0.956
Triglycerides (mg/dL)	101.7 (52.3)	101.3 (56.8)	102.1 (48.6)	0.943
HDL (mg/dL)	43.2 (9.1)	44.1 (8.6)	42.4 (10.2)	0.440
LDL (mg/dL)	75.6 (15.5)	75.2 (16.1)	75.9 (15.2)	0.848
LDL/HDL ratio	1.8 (0.6)	1.8 (0.5)	1.9 (0.6)	0.292
TC/HDL ratio	3.2 (0.8)	3.1 (0.7)	3.2 (0.8)	0.333
Metabolic index	5.9 (4.8)	5.4 (3.9)	6.4 (5.4)	0.376

SD: standard deviation; HDL; high density lipoprotein cholesterol; LDL: low density lipoprotein cholesterol; LDL/HDL: low density lipoprotein cholesterol/high density lipoprotein cholesterol ratio; TC/HDL: total cholesterol/high density lipoprotein cholesterol ratio. Independent *t*-test was applied to compare mean values of anthropometric, body composition and biochemical parameters between boys and girls.

Table 2. Associations of birthweight with anthropometric and cardiometabolic parameters.

Outcomes	Symmetrical percentage differences	95% CI		*P*-value
Body mass index (kg/m^2)	2.47	−0.64	5.60	0.119
Fat mass index (kg/m^2)	1.52	−9.54	12.58	0.785
Glucose (mg/dL)	−1.09	−2.73	0.56	0.192
Triglycerides (mg/dL)	7.56	−2.92	18.03	0.155
Total cholesterol (mg/dL)	1.16	−2.88	5.19	0.570
HDL (mg/dL)	−6.56	−11.56	−1.56	0.001
LDL (mg/dL)	4.47	−0.80	9.74	0.095
LDL/HDL ratio	11.04	3.69	18.39	0.004
TC/HDL ratio	7.75	2.26	13.24	0.006
Metabolic index	19.58	3.14	36.00	0.018

HDL: high density lipoprotein cholesterol; LDL: low density lipoprotein cholesterol; LDL/HDL: low density lipoprotein cholesterol/high density lipoprotein cholesterol ratio; TC/HDL: total cholesterol/high density lipoprotein cholesterol ratio; Each row represents a different model with children's anthropometric and biochemical parameters in the left hand column as the dependent variables and birth weight (gestational week and sex-specific z-scores) as the main independent variable. Outcomes were transformed to $y = 100 \log(e)x$ and the resulting estimates are interpreted as symmetrical percentage differences. All models were adjusted for children's sex, age (years) and crowding index in the household.

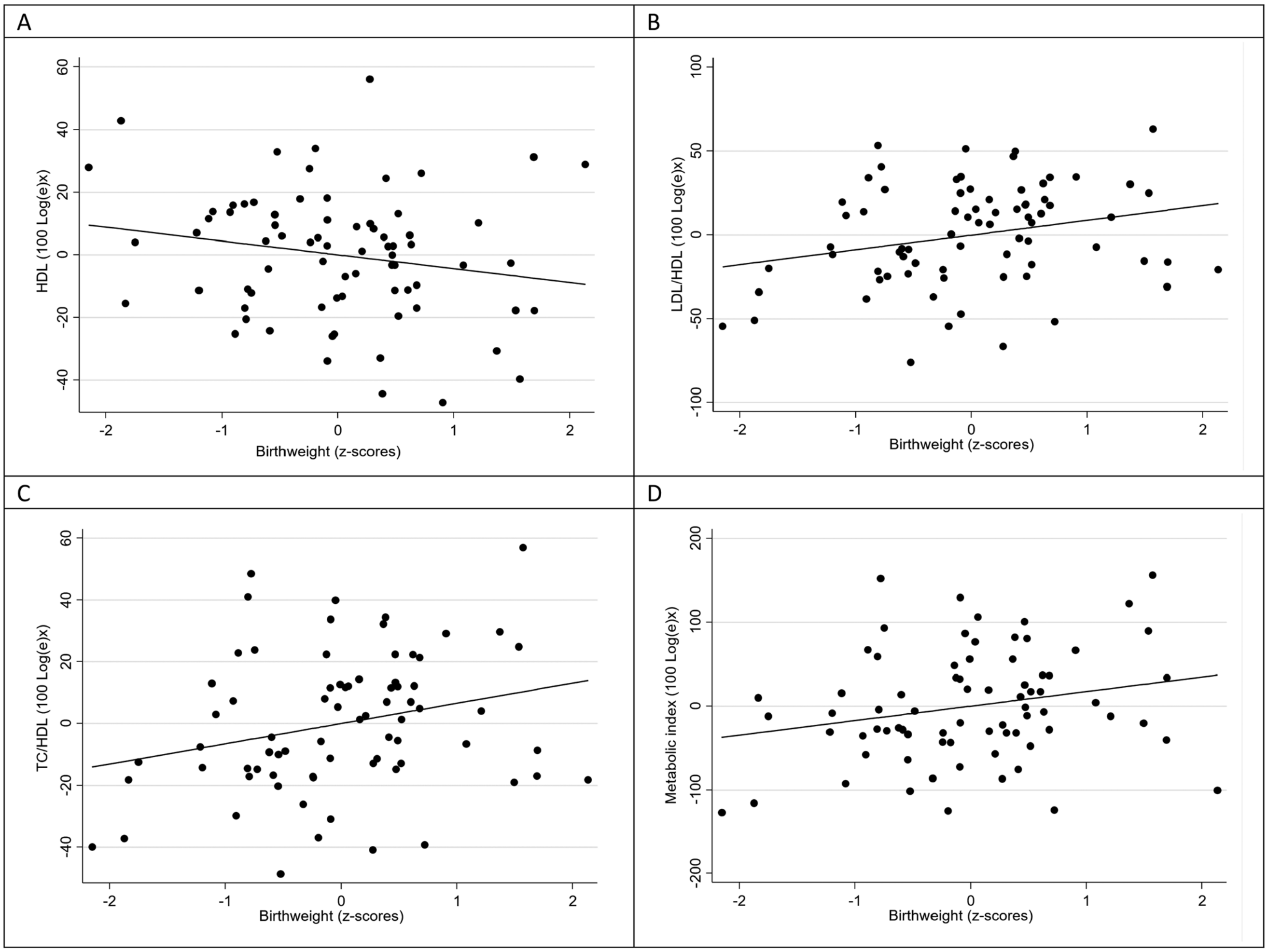

Figure 1. Partial regression plots of high density lipoprotein cholesterol (HDL) [A], low density lipoprotein cholesterol/high density lipoprotein cholesterol ratio (LDL/HDL) [B], total cholesterol/high density lipoprotein cholesterol ratio TC/HDL [C] and metabolic index [D] on birthweight (gestational week and sex-specific z-scores) accounting for children's age and sex and crowding index in the household. Outcomes were transformed to $y = 100$ log(e)x and the resulting estimates are interpreted as symmetrical percentage differences.

Discussion

In the present study, we analysed the association between birthweight and cardiometabolic risk parameters in a sample of Maya children from a small rural community of Yucatan, Mexico. Our results showed that children with greater birthweights had lower blood concentrations of HDL and higher LDL/HDL and TC/HDL ratios (Figure 1). Higher values of LDL/HDL and TC/HDL ratios and lower values of HDL are linked to cardiovascular disease in adults, in which atherosclerosis represents one of the main pathophysiological mechanisms (Gordon et al. 1977; Ballantyne and Hoogeveen 2003; Kappelle et al. 2011). Nowadays, it is well recognised that the earliest manifestations of lipid abnormalities, such as endothelial dysfunction, begin during childhood (Cote et al. 2013; Pires et al. 2016). Usually, lipid concentrations track into adulthood, particularly in the presence of a high level of body fatness (Srinivasan et al. 1996).

Interestingly, in our study, the association between children's birthweight was stronger with lipoprotein ratios than with single lipid parameters (total cholesterol and triglycerides). Several studies have shown that lipid ratios have greater capacity to predict cardiovascular risk than single standard lipid measures (Kinosian et al. 1994; Zhu et al. 2015; Wen et al.2017). For example, TC/HDL and LDL/HDL ratios have shown better capacity to predict arterial stiffness (measured by brachial-ankle pulse wave velocity) than total cholesterol in a sample of 1,015 18–44 year old men from China (Wen et al. 2017). Consistent with our results, Cowin and Emmet (2000) found that birthweight was negatively associated with HDL and positively associated with TC/HDL-C ratio in 3–4 year old children in the Avon Longitudinal Study of Parents and Children. Some other studies have found positive associations between birthweight and total cholesterol in school-age children from England (Rona et al. 1996; Mortaz et al. 2001).

In the present study, birthweight was not a good predictor of FMI. In a previous study conducted with a sample of 260 6–8 year old urban Maya children whose birthweights and levels of body adiposity were higher than rural children from Dzeal (birthweight: 3,126 g [SD = 502] vs 2,834 g [SD = 527], FMI: 5.9 kg/m^2 [SD = 2.1] vs 5.2 kg/m^2 [SD = 2.3]), birthweight was positively associated with FMI (Azcorra et al. 2021), which may suggest that the exposure to obesogenic environments during postnatal growth is relevant in the induction of body adiposity.

We also found that children's birthweight was positively associated with the metabolic index, a good indirect measure of insulin resistance, since it takes into account the levels of TG, HDL and G (Roitberg et al. 2015). This agrees with studies that relate the high concentrations of TG and low levels of HDL with insulin resistance and T2D (Bonora et al. 1998) and studies suggesting the product of TG and glucose (TGxG) in plasma as an index of insulin resistance (Guerrero-Romero et al. 2010). In this regard, TGxG and the inverse relation of HDL in metabolic index had been related with hypercholesterolaemia in adult Mayas with T2D (Lara-Riegos et al. 2018). Also, Maple-Brown et al. (2009) proposed the measurement of TG and HDL levels as a more useful clinical tool to assess cardiovascular risk in indigenous Australian youth and the estimation of the TG/HDL ratio is a marker of insulin resistance in several indigenous groups, as also demonstrated by Hirschler et al. (2015) in a sample of native children from Argentina.

A central point to discuss in our results is the direction of significant associations between birthweight and cardiometabolic risk parameters. According to the DOHaD perspective, adverse nutritional conditions experienced by individuals during their intrauterine development would predict adverse profiles in cardiometabolic outcomes, as has been found in several studies. In contrast, our results indicate that children with greater birthweights showed unfavourable values of HDL, lipoprotein ratios and indirect insulin resistance. Our study does not allow us to provide explanations on the causes of these findings. We believe that maternal body composition may be playing an important role in the phenotype and metabolism of children, but we lack data to test this hypothesis. Previous studies have shown high levels of body fatness in Maya adult women from Yucatan; even in rural communities, the prevalence of excess body weight in adult females reaches 70–80%. Maternal obesity before pregnancy is associated with a set of adverse outcomes in offspring health, including delivery of large for gestational infants (Norman and Reynolds 2011; Godfrey et al. 2017), overweight and increased concentrations of blood lipids and insulin resistance in offspring during childhood (Bekkers et al. 2011; Gaillard et al. 2014; Oostvogels et al. 2014; Gaillard et al. 2015; Maftei et al. 2015). We need longitudinal studies that incorporate the analysis of the influence of maternal factors on the phenotype and metabolism of offspring at birth and postnatal growth trajectories to advance our understanding of the cardiometabolic health of individuals from early stages in which health care and prevention strategies can be implemented.

The incorporation of the Maya communities into the socioeconomic dynamics of tourism has modified not only the livelihood of the population, but also their form of consumption. Currently, the families from Dzeal are supplied with food that is commercialised in the stores of the community and nearest communities. The deterioration in the quality of the diet has generated a substantial increase in excess weight in adults and children during the last three decades. Secular changes in nutritional status in the community showed that in 1986 and 2000, only 5% and 7% of children, respectively, met the criteria for high BMI-for-age (>85th percentile); the percentage in 2022 increased to 23% in a large sample of children from the community (Azcorra et al. 2023).

Once we have identified these parameters in a community of the Mayan rural population, we may also want to share our findings to enable interventions improving nutrition and health conditions of the newer generations of Mayan residents of Yucatan. Culturally-tailored nutritional interventions for ethnic groups around the world have shown diverse results. Newer approaches involving the youngest through precision and personalised nutrition seem to offer a promising way for addressing nutritional aspects and ultimately reducing the risk for metabolic health problems, but also require resources (Livingstone et al. 2023).

Limitations

First, the small sample size limited our ability to detect other significant relationships between birthweight and outcomes and include other variables in the analyses. Second, unfortunately we lack data on maternal body composition before conception and data on children's growth trajectories, particularly about changes in body composition; both factors may play important roles in shaping offspring phenotype and lipid profile. Finally, several studies show that blood lipid concentrations tend to vary during pubertal development (Eissa et al. 2016; Schienkiewitz et al. 2019). We decided not to obtain data on pubertal development in participants because we consider this assessment is inappropriate given the sociocultural context of the community. We are aware that the associations between birthweight and cardiometabolic levels in the adolescents of this sample may be influenced to some extent by their stage of sexual maturation. We consider this study to have a low risk of selection bias; most of the excluded participants were children in the youngest ages (3 or 4 years old) who refused to give blood samples for fear of venous puncture. The data suggest that children included in the study did not differ from excluded cases in anthropometric characteristics. The results of this study cannot be confidently generalised to the whole Maya population. It is possible that the association between birthweight and cardiometabolic parameters varies in terms of environmental factors that shape maternal phenotype and growth trajectories during childhood. The present study and studies with larger and more diverse samples will allow a better understanding of the complex relationship between birthweight and cardiometabolic health in the context of the Maya population.

Conclusion

Greater birthweights of Maya children from the studied rural Maya community were associated with lower blood concentrations of HDL and higher levels of LDL/HDL, TC/HDL ratios and indirect values of insulin resistance, which are all considered risk factors for cardiometabolic disease. Our study contributes to the knowledge on the factors that shape the health-disease process in the Maya.

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