Impact of gaining or maintaining excessive weight in infancy on markers of metabolic homeostasis in young children: A longitudinal study in Chilean children

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ABSTRACT

Childhood obesity in Chile is one of the highest in the world. The objective of this study was to assess the impact of excessive weight gained or maintained over a 3-year period, on markers of metabolic homeostasis in young children. This is a longitudinal study which includes 243 children followed from 4 to 7 years. We assessed BMI, body fat percentage, waist circumference (WC), waist-hip ratio (WHR), waist-height (WH) and trunk fat as well as the following metabolic parameters: glucose, insulin, triglycerides, total cholesterol, LDL, HDL and metabolic risk score. Kruskal-Wallis was used to assess differences in metabolic markers by nutritional status and logistic regression to determine the effect of maintaining or gaining excess weight over the 3-year period, compared with children who maintained a normal weight. Children who were obese at both ages compared with those who were normal weight, had a significantly higher WC, serum concentrations of total fat, total cholesterol, triglycerides, LDL cholesterol and metabolic risk score ($P < 0.05$). Children who were overweight or obese at 4 and 7 years, had a greater risk of having a high WC (OR: 3.37; $P = 0.03$), total cholesterol (OR: 4.17; $P < 0.003$), triglycerides (OR: 1.96; $P = 0.04$); thus a higher metabolic risk score (OR: 3.21; $P = 0.003$). Excess weight maintained over time in early childhood, significantly increases the risk of having higher serum biomarkers of cardiovascular risk, which in turn determines the magnitude of cardiovascular and metabolic risks later in life.

1. Introduction

Obesity in early childhood is a public health problem in virtually all countries except for sub Saharan Africa and South Asia. It has been shown that it is associated with early onset type 2 diabetes and atherogenic processes that predispose young people to chronic diseases (Yeste and Carrascosa, 2011; Sinaiko, 2012). Cohort studies in adults show that these conditions individually or grouped under the definition of the Metabolic Syndrome (MS), determine an increased risk of cardiovascular disease (myocardial infarction, stroke, sudden death) and early mortality (Sinaiko, 2012; Poyrazoglu et al., 2014). Studies assessing tracking of adiposity into adulthood show that magnitude of the effect is dependent on the age of onset (Rolland-Cachera et al., 1987; Power et al., 1997). An early adiposity rebound recorded in most obese subjects suggests that factors promoting body fat accumulation operate early in life (Rolland-Cachera et al., 1987; Rolland-Cachera et al., 2006). Recent evidence on the relationship between child and adolescent obesity and adult adiposity shows significant tracking of early adiposity, suggesting that the increased cardiovascular risk of adult obesity may be mediated by childhood weight status (Power et al., 1997; Freedman et al., 2001; Freedman et al., 2007).

Adipose tissue is actively involved in regulating metabolic homeostasis and physiological functions such as immunity and inflammation. Adipose tissue produces and secretes adipokines (leptin, adiponectin, resistin, visfatin) and cytokines mainly tumor necrosis factor alpha, interleukin-6 and inflammatory proteins. Increase in cytokines release either as adipokines or by macrophages infiltrating adipose tissue, leads to chronic inflammation. This phenomenon plays a central role in the development of insulin resistance and type 2 diabetes mellitus, and explains the increased risk of cardiovascular disease associated with obesity (Pearson et al., 2003; Blankenberg et al., 2003; Antuna-Puente et al., 2008). These novel biomarkers may be stronger than conventional measures of lipoprotein concentrations as risk factors to predict future cardiovascular events. This provides an opportunity to assess the various causal pathways to take preventive action, focusing on early stages of the life course (Pearson et al., 2003; Blankenberg et al., 2003;
Antuna-Puente et al., 2008; Steinberger et al., 2009).

Unhealthy lifestyles associated with an increased intake of a high fat/sugar diet, low physical activity and caloric imbalance, have shown to promote the development of cardiovascular and metabolic diseases (Hamilton et al., 2007; Lloyd-Jones et al., 2010). Hence, the contribution of adiposity “per se” to overall later life cardiometabolic risk in children remains uncertain. Therefore, the aim of this study was to assess the impact of excessive weight gained during infancy and/or maintained over a 3-year period (4 to 7 years of age) on metabolic markers of glucose and fat homeostasis in young children.

2. Materials and methods

2.1. Subjects

The sample included 243 children, from the Growth and Obesity Chilean Cohort Study (GOCS), whose initial objective was to evaluate the interaction between the rate of infant growth (changes in size and BMI between birth and 2 years) and family history of obesity, on adiposity (measured by both BMI and body fat percentage) of 1196 preschool children (4 years old) born with normal birth weight. The present study plan is to follow this cohort to adolescence.

The children included in the present report were selected randomly from the GOCS population at 4 years of age. Anthropometric measures and metabolic parameters were measured in 104 girls and 139 boys at 4 and 7 years, thus all were followed for 3 years. A signed informed consent was obtained from one of the parents or legal guardian. The Ethics Committee of the Institute of Nutrition and Food Technology (INTA), University of Chile, which meets national and international standards, approved the study.

2.2. Anthropometric measurements

Two trained experienced nutritionists using standardized procedures, measured weight, height, waist, circumference hip and triceps, biceps, subscapular and suprailiac skinfold thicknesses. Weight (kg) and height (cm) were measured in the morning, with minimal clothing (underwear only) with children standing on a portable electronic scale (Seca 770, SECA®, Hamburg, Germany), with capacity up to 200 kg and accuracy of 10 g. Height was measured with a portable stadiometer (Harpenden 603; Holtain Ltd., Crosswell, UK) with a scale of 1 to 200 cm. and accuracy of 0.5 cm. WC (cm) was measured over the iliac crest, through the umbilicus. Hip circumference (cm) was measured in standing position, at the widest part of the gluteal region, at the level of the greater trochanter using an non-extendible metal, self-locking tape (Luftin W606 PM; Cooper Tools, Raleigh, North Carolina), with accuracy of 0.1 cm. Skinfold thicknesses (mm) (biceps, triceps, subscapular and suprailiac) were measured with a millimeter precision Lange Caliper (1 mm) (Lohman et al., 1984). These skinfolds were used to determine total body fat using anthropometric models (Velásquez et al., 2008; Aguirre et al., 2015). The intra-observer technical error of measurement and mean observer bias were within the limits suggested by the World Health Organization (WHO, 2006a).

2.3. Blood samples

A trained nurse collected a sample of fasting venous blood (25 ml) of children. Mothers were contacted the day before to confirm the absence of fever (> 37.5 °C) or symptoms of acute infection in children as well as to remind them that the children had to fast the following morning. These conditions were re-checked by the nurse at the time of blood drawing, and exams were rescheduled in conditions were not met. Blood samples were analyzed at the Nutrition Laboratory at the Catholic University Medical Center. This laboratory conducts daily assessments of the accuracy of the measurements using quality control software's (Bio-Rad Laboratories Inc., Hercules, CA) and lipid measurements, and it has a Certificate of Traceability periodically updated by the Centers for Disease Control and Prevention (CDC) (Rudolf et al., 2004; Warolin et al., 2014). Serum glucose levels were measured using enzymatic colorimetric techniques (HUMAN; Gesellschaft für Diagnose und Biochemical, Wiesbaden, Germany) and serum insulin was measured with a radioimmunossay kit (Linco Research Inc., St. Charles, MO). The HOMA-IR was calculated as fasting glucose (mmol/L) fasting insulin (mU/mL)/22.5. Total cholesterol and triglycerides were measured using enzymatic colorimetric techniques (HUMAN).

HDL was isolated by precipitation with a solution of sodium phosphotungstate magnesium chloride (Seigler and Wu, 1981). LDL cholesterol was calculated using the Friedewald formula (i.e., all concentrations of triglycerides were < 400 mg/dL) (Friedewald et al., 1972).

2.4. Anthropometric indices

BMI was estimated as kg/m². Standard scores (z score) of weight for age (WAZ), height for age (HAZ), and BMI-for-age (BAZ) were estimated comparing values with the WHO reference 2006 (WHO, 2006b). Normal nutritional status was defined as (−1 < BAZ ≤ 1), overweight as (1 ≤ BAZ < 2) and obesity as (BAZ > 2 SD). Central obesity: Boys WC ≥ 90th percentile in 4 years (57.61±2 cm) and 7 years (67.8 cm). Girls: WC ≥ 90th percentile in 4 years (58.3 cm) and 7 years (67.5 cm) (Fernandez et al., 2004). WC divided by height and hip circumference was used to calculate the WH and WHR, respectively. Triceps, biceps, subscapular and suprailiac and the abdominal, subscapular and suprailiac thicknesses were used to estimate total body fat and body fat trunks, respectively. In order to estimate the percentage of body fat at 4 and 7 years, we used predictive equations, calculated for Chilean children. At 4 years (Velásquez et al., 2008), the following predictive equation was used: [-1.524 + (0.371 * weight kg) + 0.114 * (triceps thicknesses mm + subscapular thicknesses mm) − (0.238 + age years) + (0.378 + gender 1 boys, 2 girls) − (0.105 + calf circumference)] while at 7 years we used a prediction equation previously developed in a subsample of 7–9 years old children from this same cohort and validated by deuterium dilution (Aguirre et al., 2015). This equation is: (1.826 × ZBMI) + (0.783 × triceps skinfold) + (0.3073 × biceps skinfold) + 15.558, against 3C model (R² = 0.78).

2.5. Metabolic risk factors

The cutoff points used to define abnormal cardiometabolic status were: glucose concentration ≥ 100 mg/dl (American Diabetes Association, 2006); HOMA-IR ≥ 3.2 (Kurtoglu et al., 2005); total cholesterol, LDL cholesterol and triglycerides ≥ 95th percentile [American Academy of Pediatrics: girls (total cholesterol ≥ 197 mg/dl, LDL cholesterol ≥ 140 mg/dl and triglycerides ≥ 120 mg/dL), and boys (total cholesterol ≥ 186 mg/dl, LDL cholesterol ≥ 129 mg/dl, and triglycerides ≥ 85 mg/dl) (Daniels, Greer and Committee on Nutrition, 2008); HDL cholesterol ≤ 5th centile [American Academy of Pediatrics: girls (38 mg/dl) and boys (36 mg/dl)] (Zimmet et al., 2007). Metabolic syndrome risk score was determined by adding the standardized Z scores for waist circumference, glucose, insulin, triglycerides and inverse HDL-cholesterol dividing the sum by 5 (Brage et al., 2004; Zimmet et al., 2007).

2.6. Statistical analyses

Mean values and standard deviations were calculated for continuous and frequency distributions for categorical variables. Student test was used to assess differences in continuous and Chi-square and Fisher's exact tests for categorical variables. Student t test was also used to compare differences in metabolic variables by sex and nutritional status at 4 and 7 years and Chi-square and Fisher's exact test to compare the prevalence of metabolic markers at 4 and 7 years for both sexes.

Based on the changes of the children’s nutritional status over the 3-
Anthropometric characteristics of the sample by age and sex.a

| Variable                  | 4 years                      | 7 years                      | P valueb     | 4 years                      | 7 years                      | P valueb     |
|---------------------------|------------------------------|------------------------------|--------------|------------------------------|------------------------------|--------------|
| Age (years)               | Boys (n = 139)               | Girls (n = 104)              | P valuec     | Boys (n = 139)               | Girls (n = 104)              | P valuec     |
| Weight (kg)               | 4.25 ± 0.3                   | 4.27 ± 0.3                   | 0.64         | 6.95 ± 0.4                   | 6.94 ± 0.4                   | 0.87         |
| BMI (kg/m²)               | 17.7 ± 2.3                   | 17.9 ± 2.8                   | 0.52         | 25.5 ± 4.8                   | 25.7 ± 4.9                   | 0.81         |
| Waist-to-hip ratio        | 0.93 ± 0.0                   | 0.90 ± 0.0                   | <0.0001      | 0.90 ± 0.0                   | 0.88 ± 0.0                   | <0.001       |
| Waist-to-height ratio     | 0.51 ± 0.0                   | 0.51 ± 0.0                   | 0.83         | 0.48 ± 0.1                   | 0.48 ± 0.1                   | 0.97         |
| Sum of 4 skinfold (mm)    | 24.2 ± 8.9                   | 30.8 ± 13.9                  | <0.0001      | 25.9 ± 10.0                  | 30.7 ± 12.0                  | <0.0001      |
| Total fat (%)             | 19.3 ± 3.8                   | 22.8 ± 6.6                   | <0.0001      | 23.1 ± 10.4                  | 27.4 ± 11.2                  | <0.001       |
| Body fat index (kg/m²)    | 3.2 ± 0.9                    | 3.8 ± 1.5                    | <0.0001      | 4.3 ± 1.6                    | 4.5 ± 1.6                    | 0.26         |
| Normal weighta            | 66.2 (92)d                   | 68.3 (71)d                   | 0.77         | 62.6 (87)e                   | 66.4 (69)f                   | 0.62         |
| Overweight/obesea         | 33.8 (47)d                   | 31.7 (33)d                   | 0.73         | 37.4 (52)d                   | 33.6 (35)d                   | 0.72         |

a WHO 2006, World Health Organization; NHANES III, National Health and Nutrition Examination Survey.
b Values expressed as mean ± SD: standard deviation.
c Sex differences assessed by using Student’s t-test or chi-square test.
d Values expressed as (% (n)).
e Calculated by summing biceps, triceps, suprailiac and subscapular skinfold thicknesses.
f Calculated by summing abdominal, suprailiac and subscapular skinfold thicknesses.
g Calculated specifically by increased total fat, WC, HOMA-IR, total cholesterol, LDL-cholesterol and triglycerides (P < 0.05).
h Estimated on the basis of a predictive equation that uses BMIZ, biceps and triceps skinfold thicknesses.
i Estimated on the basis of a predictive equation that uses BMIZ, biceps and triceps skinfold thicknesses.

In a contemporary cohort of Chilean children with a three year follow-up (4 to 7 years), we found that overweight and obesity in young children are associated with disruption of metabolic homeostasis reflected specifically by increased total fat, WC, HOMA-IR, total cholesterol, LDL cholesterol, triglycerides, fasting insulin and metabolic risk score (P < 0.05). Children who were overweight or obese at 4 and 7 years, showed a significant deterioration of their cardiometabolic profile. These results are similar to those obtained in a cohort of Korean children (n = 109, mean age 10.5 ± 0.4 y), evaluated after a two year
Table 2
Metabolic characteristics of the sample at 4 and 7 years, by sex and age.

| Variable                        | 4 years          | 7 years          | P value^c | 4 years          | 7 years          | P value^c |
|---------------------------------|------------------|------------------|-----------|------------------|------------------|-----------|
| Boys (n = 139)                  |                  |                  |           |                  |                  |           |
| Waist circumference (cm)        | 52.5 ± 3.5       | 58.9 ± 6.7       | < 0.001   | 9.4 (13)         | 11.5 (16)        | 0.56      |
| Fasting glucose (mg/dL)         | 80.8 ± 9.1       | 90.8 ± 6.3       | < 0.001   | 3.6 (5)          | 7.4 (10)         | 0.17      |
| HOMA-IR                         | 1.31 ± 0.6       | 1.22 ± 0.4       | 0.16      | 2.2 (3)          | 0.7 (1)          | 0.33      |
| Total cholesterol (mg/dL)       | 163.2 ± 26.6     | 167.8 ± 26.3     | 0.09      | 19.4 (27)        | 26.7 (36)        | 0.15      |
| LDL cholesterol (mg/dL)         | 111.4 ± 25.2     | 97.3 ± 27.6      | < 0.001   | 23.7 (33)        | 13.0 (17)        | 0.02      |
| HDL cholesterol (mg/dL)         | 36.4 ± 9.5       | 50.2 ± 15.4      | < 0.001   | 54.7 (76)        | 18.9 (25)        | < 0.001   |
| Triglycerides (mg/dL)           | 77.3 ± 30.5      | 107.2 ± 52.6     | < 0.001   | 30.9 (43)        | 54.8 (74)        | < 0.001   |
| Fasting insulin (μU/mL)         | 6.4 ± 2.4        | 5.4 ± 1.4        | < 0.001   | –                | –                | –         |
| Metabolic risk score^b          | 0.01 ± 0.5       | 0.12 ± 0.4       | 0.02      | 23.7 (33)        | 28.2 (38)        | 0.41      |
| Girls (n = 104)                 |                  |                  |           |                  |                  |           |
| Waist circumference (cm)        | 52.6 ± 4.4       | 58.9 ± 6.8       | < 0.001   | 12.5 (13)        | 14.4 (15)        | 0.68      |
| Fasting glucose (mg/dL)         | 77.3 ± 6.6       | 89.9 ± 5.9       | < 0.001   | 1.0 (1)          | 4.1 (4)          | 0.15      |
| HOMA-IR                         | 1.27 ± 0.7       | 1.30 ± 0.6       | 0.74      | 1.9 (2)          | 3.1 (3)          | 0.60      |
| Total cholesterol (mg/dL)       | 169.4 ± 25.8     | 172.6 ± 26.4     | 0.28      | 14.4 (15)        | 15.3 (15)        | 0.86      |
| LDL cholesterol (mg/dL)         | 114.1 ± 26.5     | 104.9 ± 30.7     | 0.002     | 16.4 (17)        | 9.2 (9)          | 0.13      |
| HDL cholesterol (mg/dL)         | 37.8 ± 9.8       | 50.4 ± 12.3      | < 0.001   | 50.5 (52)        | 14.3 (14)        | < 0.001   |
| Triglycerides (mg/dL)           | 88.6 ± 32.9      | 98.2 ± 50.8      | 0.04      | 17.3 (18)        | 26.5 (26)        | 0.11      |
| Fasting insulin (μU/mL)         | 6.5 ± 2.6        | 5.88 ± 2.5       | 0.05      | –                | –                | –         |
| Metabolic risk score^b          | −0.06 ± 0.6      | 0.09 ± 0.6       | 0.04      | 29.8 (31)        | 22.5 (22)        | 0.23      |

^a Cutoff points for risk factors were the following: 4 years: boys: waist circumference 90th percentile = 57.6 cm. Girls: waist circumference 90th percentile = 58.3 cm. 7 years: Boys: 90th percentile = 67.8 cm. Girls: 90th percentile = 67.5 cm; glucose ≤ 100 mg/dL; HOMA-IR ≥ 3.2; total cholesterol, LDL cholesterol and triglycerides ≥ 95th percentile [American Academy of Pediatrics: girls (total cholesterol ≥ 197 mg/dL. LDL cholesterol ≥ 140 mg/dL and triglycerides ≥ 120 mg/dL); and boys (total cholesterol ≥ 186 mg/dL. LDL cholesterol ≥ 129 mg/dL and triglycerides ≥ 85 mg/dL)]; and HDL cholesterol ≤ 5th percentile [American Academy of Pediatrics: girls (38 mg/dL) and boys (36 mg/dL)].

^b Age differences assessed by Student's t-test.

^c Age differences assessed by Chi-square or Fisher's exact test.

^d Values expressed as Mean ± SD.

^e Values expressed as (% (n)).

^f Metabolic risk score: SDS (waist circumference + glucose + insulin + triglycerides − HDL-cholesterol / 5).

Table 3
Mean concentrations of metabolic variables by nutritional status at 4 and 7 years (BAZ; World Health Organization, 2006a).^a

| Variable                        | 4 years (n = 243) | 7 years (n = 243) | P value^c | 4 years (n = 243) | 7 years (n = 243) | P value^c |
|---------------------------------|------------------|------------------|-----------|------------------|------------------|-----------|
| BAZ                             |                  |                  |           |                  |                  |           |
| Normal weight (n = 163)         | 0.14 ± 0.6       | 1.91 ± 0.8       | < 0.001   | 0.04 ± 0.7       | 2.1 ± 0.6        | < 0.001   |
| Overweight/obese (n = 80)       | 19.0 ± 4.3       | 24.4 ± 5.8       | < 0.001   | 22.0 ± 2.2       | 30.5 ± 3.8       | < 0.001   |
| Waist circumference (cm)        | 50.9 ± 2.6       | 56.0 ± 3.9       | < 0.001   | 55.1 ± 3.3       | 65.8 ± 5.7       | < 0.001   |
| Fasting glucose (mg/dL)         | 78.1 ± 6.7       | 80.0 ± 8.8       | 0.09      | 89.9 ± 6.0       | 91.4 ± 6.1       | 0.08      |
| HOMA-IR                         | 1.26 ± 0.6       | 1.36 ± 0.8       | 0.27      | 1.17 ± 0.2       | 1.41 ± 0.8       | < 0.001   |
| Total cholesterol (mg/dL)       | 165.1 ± 27.0     | 167.7 ± 26.6     | 0.47      | 166.0 ± 24.9     | 176.7 ± 27.7     | 0.003     |
| LDL cholesterol (mg/dL)         | 111.2 ± 26.5     | 114.7 ± 25.2     | 0.33      | 96.9 ± 25.3      | 106.0 ± 34.21    | 0.02      |
| HDL cholesterol (mg/dL)         | 37.3 ± 10.1      | 36.6 ± 9.2       | 0.62      | 50.8 ± 14.6      | 49.4 ± 13.5      | 0.48      |
| Triglycerides (mg/dL)           | 82.6 ± 32.9      | 82.2 ± 34.2      | 0.93      | 91.4 ± 41.2      | 117.7 ± 63.8     | 0.002     |
| Fasting insulin (μU/mL)         | 6.3 ± 2.1        | 7.0 ± 3.2        | 0.04      | 5.3 ± 0.6        | 6.2 ± 3.0        | < 0.001   |
| Metabolic risk score^b          | −0.1 ± 0.5       | 0.2 ± 0.6        | < 0.001   | −0.1 ± 0.3       | 0.5 ± 0.4        | < 0.001   |

^a WHO 2006. World Health Organization; NHANES III. Third National Health and Nutrition Examination Survey.

^b Nutritional Status differences assessed by Student’s t-test.

^c Metabolic risk score: SDS (waist circumference + glucose + insulin + triglycerides − HDL-cholesterol / 5).
Table 4
Cardiometabolic characteristics of the sample in children who maintained or changed their nutritional status between 4 and 7 years.

| Variable                     | N-N (n = 132) | OW-N (n = 24) | N-OW (n = 31) | OB-OB (n = 56) | P value |
|------------------------------|---------------|---------------|---------------|----------------|---------|
| BAZ (µg/mL)                  | −0.07 ± 0.64c | 0.67 ± 0.29e  | 1.57 ± 0.6d   | 2.47 ± 0.66e   | <0.001  |
| Total fat (%)                | 21.7 ± 2.16e  | 23.3 ± 2.46d  | 28.4 ± 3.1bd  | 31.7 ± 3.66c   | <0.001  |
| Waist circumference (cm)     | 54.8 ± 3.36c  | 56.4 ± 3.26e  | 62.6 ± 4.36d  | 67.6 ± 5.56e   | <0.001  |
| Fasting glucose (mg/dL)      | 90.3 ± 6.0    | 88.0 ± 5.9    | 91.6 ± 6.0    | 91.2 ± 6.2     | 0.15    |
| Total cholesterol (mg/dL)    | 166.4 ± 24.5b | 163.9 ± 27.1c | 168.1 ± 23.7  | 181.5 ± 28.84c | 0.01    |
| Triglycerides (mg/dL)        | 91.1 ± 39.7b  | 92.9 ± 49.3   | 104.8 ± 45.9  | 125.0 ± 71.3b  | 0.05    |
| HDL cholesterol (mg/dL)      | 49.5 ± 14.2   | 57.6 ± 14.9   | 48.2 ± 12.4   | 50.1 ± 14.1    | 0.05    |
| LDL cholesterol (mg/dL)      | 98.6 ± 24.9   | 87.7 ± 25.3   | 99.0 ± 25.7   | 110.1 ± 37.9b  | 0.03    |
| Fasting insulin (µU/mL)      | 5.3 ± 0.6     | 5.3 ± 0.7     | 5.2 ± 0.5     | 6.7 ± 3.7      | 0.29    |
| Metabolic risk score         | −0.1 ± 0.36c  | −0.2 ± 0.3d   | 0.2 ± 0.36d   | 0.6 ± 0.75c    | <0.001  |

N: Normal to normal (N-N); overweight/obese to normal (OW-N); normal to overweight/obese (N-OW) and obese-obese (OB-OB).

b,c,d,e=Equal numbers indicate significant differences between groups (post-hoc Bonferroni) (P < 0.05).

Table 5
Multiple logistic regression model for the association of metabolic risk with change in nutritional status, adjusted by sex and age.

| Variable                     | ORa | SEb | (95% CI)c | P value |
|------------------------------|-----|-----|-----------|---------|
| Initial metabolic risk       | 3.08| 1.15| 1.48-6.41 | 0.003   |
| Change in nutritional status |     |     |           |         |
| OW-N                         | 0.34| 0.37| 0.04-2.78 | 0.31    |
| N-OW                         | 4.07| 1.98| 1.57-10.57| 0.004   |
| OB-OB                        | 8.39| 3.38| 3.81-18.49| <0.001  |
| Sex                          | 0.73| 0.27| 0.36-1.49 | 0.39    |
| Age                          | 2.48| 1.21| 0.95-6.48 | 0.06    |

a Logistic regression model. Hosmer-Lemeshow (P = 0.5810) indicated that the goodness of fit of the model is satisfactory.

b OR: odds ratio.
c SE: standard error.
d (95% CI): 95% confidence interval.

5. Conclusions
Children who were overweight or obese as well those who maintained their overweight status between 4 and 7 years of age, showed a significant deterioration of their cardiometabolic profile. Maintaining an excess weight over time in early childhood may lead to cardiovascular risks that correlate directly with the presence and magnitude of cardiovascular and metabolic abnormalities.

Competing interests
The authors declare no conflicts of interest.

Authors’ contributions
FV participated in data collection, obtained and interpreted the data set, and wrote the manuscript; CC initiated the study, assisted in interpretation of results and writing the manuscript; RU initiated the study; JK assisted in interpretation of results and writing the manuscript.

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