Prematurity and Body Fat at 6, 18, and 30 Years of Age: Pelotas (Brazil) 2004, 1993, and 1982 Birth Cohorts

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Abstract

Background: Our aim was to investigate the association between preterm birth and body fat at 6, 18, and 30 years of age using data from three population-based birth cohort studies.

Methods: Information on gestational age (GA) gathered in the hospital of birth in the first 24-hours after the delivery was obtained for all live births occurring in the city of Pelotas, Brazil, in the years 2004, 1993 and 1982. GA was defined by the date of last menstrual period and was later categorized in ≤33, 34-36 and ≥37 weeks. Body fat was assessed by air-displacement plethysmography. Outcomes included fat mass (FM, kg), percent fat mass (%FM), fat mass index (FMI, kg/m^2), and body mass index (BMI, kg/m^2) at 18 years in the 1993 cohort and at 30 years in the 1982 cohort; and BMI Z-score, at 6 years in the 2004 cohort. Crude and adjusted linear regression provided beta coefficients with 95% confidence intervals (95%CI).

Results: A total of 3036, 3027, and 2417 participants, respectively, from the 2004, 1993, and 1982 cohorts were analyzed. At 6 years, boys born at 34-36 weeks GA presented lower adjusted mean %FM (β: -2.91%; -4.45--1.36), FMI (β: -0.70 kg/m^2 ; -1.13--0.28) and BMI Z-score (β: -0.48 kg/m^2 ; -0.79--0.16), when compared to boys born at term (≥37). At 30 years, FM (15.6kg; 0.40-30.90), %FM (13.65%; 1.38-25.92) and FMI (5.3kg/m^2; 0.30-10.37) were higher among males born at ≤33 weeks, with no statistical difference as compared to those born at term. No association was found between GA and body fat at the 1993 cohort (18 years) for both sexes.

Conclusions: Given the large number of preterm infants born each year, prevention of prematurity is essential as there are possible links between body composition and diseases later in life.

Background

Prematurity is globally recognized as a public health problem since its complications are the leading cause of neonatal and infant deaths in middle- and upper-income countries,(1) including Brazil.(2, 3, 4) Preterm babies (i.e., babies born before 37 weeks of pregnancy)(5) account for an estimated 15 million births worldwide annually, resulting in approximately 1 million deaths among children under five years of age.(6) In comparison to those born at term, preterm babies have worse health outcomes(7) and higher mortality risk.(8, 9) Brazil is the 10th country in the world with the highest absolute number of preterm births(5, 10) with prevalence ranging from 3.4–15.0% according to the region of the country.(11)

The development of metabolic functions can be initiated in the fetal stage, and an imbalance in intrauterine conditions would trigger an adaptive process aiming at survival in more critical conditions, as stated by the theory of Developmental Origins of Health and Disease (DoHaD).(12) Preterm birth, through metabolic changes, including reduced insulin sensitivity, may increase the risk of adult obesity and noncommunicable diseases, such as diabetes mellitus, arterial hypertension, and coronary heart disease. Studies also suggest that such changes are different in males and females.(13, 14)

The body composition of an individual reflects the accumulation of nutrients acquired and retained by the body over time. Fat mass is the most variable component of body composition, ranging from 6% to more than 60% of total body weight.(15) At all stages of life, excess body fat is widely recognized as a serious public health problem of global relevance.(16) In Brazil, national surveys showed that the prevalence of obesity is high ranging from 14.5 to 23.8%, depending on the region of the country.(17)
The investigation of body composition according to the gestational age (GA) at birth is scarcely reported in the literature, and life course analyses are practically nonexistent. Among the few studies that evaluated this relationship, individuals born preterm had higher body fat in childhood(18), adolescence(19) and adult life(20), compared to those born at term. Thus, the main objective of this study was to evaluate, in three different cohorts, the association between prematurity and body fat indicators at 6, 18, and 30 years of age, among participants of The Pelotas (Brazil) 2004, 1993 and 1982 Birth Cohort Study, respectively.

Methods

Sample population

Pelotas is a city in southern Brazil with a population of 328275 inhabitants and a Human Development Index of 0.739.(21) In 1982, 1993, and 2004, all hospital-born children in the city of Pelotas were followed within three cohort studies using similar methods.(22) For the current study, we used data collected at birth and at follow-up visits at the age of 6, 18 and 30 years, respectively of the 2004, 1993 and 1982 cohorts. At these follow-ups, participants were invited to attend a research clinic specially designed for the Pelotas birth cohort studies. Details on the studies methods are available in previous publications.(23,24,25) All participants with available data on GA and body composition from the studied follow-ups were included in the present analyses. Multiple births and children with congenital malformations that would interfere with feeding and walking were excluded.

Gestational age

In 1993 and 2004, the algorithm proposed by the National Center for Health Statistics (NCHS) (26) was used to estimate gestational age (GA) at birth. The estimated age was based on the last menstrual period whenever it was consistent with birth weight, length, and head circumference, according to the standard curves for these parameters for each week of gestational age.(27) In case the last menstrual period-based gestational age was unknown or inconsistent, the clinical maturity estimate based on the Dubowitz method was adopted.(28) Dubowitz is determined by inspection of various physical signs and neurological characteristics that vary with fetal age and maturity and consists of 34 items grouped into six dimensions: tone, type of tone, reflexes, movements, abnormal signs, and behavior. In 1982, GA at birth was calculated based on the date of the last menstrual period, and children whose birth weight was incompatible with standards for the estimated age were considered of unknown GA. All participants born before 37 weeks were considered preterm. For analysis, GA was categorized into three groups (≤33, 34-36 and ≥37 weeks).

Body and fat measurements

At the three cohorts, the main outcomes for this study were fat mass (FM) in kilograms, percentage of fat mass (%FM), fat mass index (FMI) and body mass index (BMI). FMI was calculated from the ratio of fat mass (kg) and height in square meters (m²), and BMI was calculated by the ratio of weight (kg) and height in m². For the 2004 cohort, BMI Z-scores specific for sex and age were calculated according to the growth curves published by World Health Organization (WHO) in 2006(29) using ANTHRO 2005 software downloaded from the WHO website (http://www.who.int/childgrowth/software/en/). Height was measured twice by trained anthropometrists using a Harpenden metal stadiometer, with 1 mm precision (Holtain, Crymych, UK) and weight was assessed using a high precision scale (0.01 kg), part of the BodPodà machine (Cosmed, Italy, http://goo.gl/7jzfLc) used for body composition assessment.
At the three cohorts, body fat was evaluated by air-displacement plethysmography with the equipment BodPodâ handled by specifically trained technicians. Plethysmography is a safe, fast, and non-invasive method that can be applied in different population groups (obese individuals, children, adults, and the elderly).(30) For this measure, participants remain inside the device, a closed chamber, for a few seconds without moving. To measure with adequate accuracy and minimize disparities in body volume measurement, it is necessary to eliminate the effect of the volume of clothing, hair, body surface, and lung, so all participants were provided with appropriate clothing. Sets of a rubber (swimming) cap and clothes specially made (shorts and elastane tank top) were provided to the cohorts’ participants. To avoid having a disposable pipe and mouthpiece for each individual, a predictor of thoracic gas volume was used based on the participant's age, sex and height.(31) Standard equations were used to define body fat by air displacement plethysmography at 6 (32) and at 18 and 30 years of age.(33)

**Covariables**

Maternal covariables were collected in the first 24 hours after delivery during the mothers’ stay at the hospital. Trained interviewers recruited and interviewed the mothers and evaluated the newborns at maternity hospitals. Maternal education level in number of full years at school (later categorized in 0-4, 5-8, 9-11, and ≥12 years), age (later categorized in <20, 20-34 and >34 years), smoking during pregnancy (smoking at least one cigarette per day, every day in any trimester of pregnancy - no; yes), family income during the month prior to the child's birth, in tertiles (1st poorest; 2nd; 3th wealthiest), and maternal pre-gestational BMI were gathered for the three cohorts. Maternal pre-gestational BMI was classified as underweight (£18.49 kg/m²), adequate (18.5 to 24.9 kg/m²), overweight (25.0 to 29.9 kg/m²), and obesity (≥30 kg/m²).(34)

For the participants, the co-variables sex (male; female), skin color (white; non-white), birth weight (kg) and length were employed. Birth weight was measured by the hospital staff using electronic pediatric scales (Harpenden@) with a precision of 10 grams, daily checked for accuracy by the research team. Birth length was measured by the study team with stadiometers accurate to 1 mm.

**Statistical analyses**

All statistical analyses were performed using Stata version 14.0 (Stata Corp., College Station, USA). Firstly, the three cohorts were described according to maternal and child characteristics and in terms of current mean and standard deviation (SD) of FM, %FM, FMI, and BMI or BMI Z-score. In these analyses, chi-square and one-way ANOVA were used where appropriate. The difference between each variable among the 3 cohorts was analyzed with chi-square test.

Although there was no evidence of interaction between GA and sex among participants from the 2004 and 1993 cohorts, in the 1982 cohort the p-values for interaction tests between GA and sex over FM, %FM, FMI, and BMI were 0.096, 0.104, 0.099, and 0.115, respectively. Then, to exhibit similar data in the three cohorts, all the analyses were stratified by sex. Interaction between GA and skin color (35) was tested, but the results were non-significant in both sexes.

The strength of the association of prematurity with body fat indicators and BMI was analyzed by linear regression. Beta coefficients with respective 95% confidence intervals (95%CI) for FM, %FM, FMI, and BMI or BMI Z-score were obtained. Adjusted hierarchical analyses were performed based on a theoretical model built by the authors. The first level was composed by the variables maternal education, maternal age, and family income; the second level, by maternal smoking during pregnancy and pre-gestational BMI; and the third and most proximal level, by skin color and
birth weight and length. At each level, the p-value of the variables was verified, and those variables with the largest p-value were removed one-by-one from the model. Variables associated with the outcome at a p-value <0.20 were kept in the model to control for possible confounding effect. The variables maintained for adjustment varied according to the outcome. The statistical analyses were performed assuming a level of significance of 5%.

As a complementary analysis, to evaluate a possible cohort effect of GA on body composition, we evaluated the difference in BMI Z-score within the 1982, 1993 and 2004 cohorts with data gathered between 3 and 4 years of age.

Ethical approval

All visits of the Pelotas 1982, 1993, and 2004 cohorts were approved by the Research Ethics Committee of the Faculty of Medicine at the Federal University of Pelotas. All methods were performed in accordance with the relevant guidelines and regulations and were approved under the protocols number 35/10 for the 2004 cohort (at 6 years), 05/11 for the 1993 cohort (at 18 years) and 16/12 for the 1982 cohort (at 30 years). Written informed consent was obtained from participants of the 1982 and 1993 cohort before the interview. For participants of the 2004 cohort, written informed consent was obtained from the mother or the legal guardian.

Results

The number of live births enrolled in the cohorts was 4231 in 2004, 5249 in 1933, and 5914 in 1982. The follow-up rates at 6, 18 and 30 years in the 2004, 1993 and 1982 cohort were 90.2%, 81.3% and 63.0%, respectively. The mean age of the 2004, 1993 and 1982 cohort members at the follow-up visit was 6.7 (SD=0.2), 18.4 (SD=0.3) and 30.2 (SD=0.3) years, respectively. Except for child’s sex, there were changes in the prevalence of all other variables between 1982 and 2004 (Table 1). Between 1982 and 2004 there were an improvement in maternal education, an increase in the prevalence of mothers aged ≥ 35 years at the birth of their child and an increase in pre-pregnancy obesity. In relation to smoking during pregnancy, there was a reduction over the years. There was also an increase in the prevalence of low birth weight and premature births, especially in late preterm (34-36 weeks of GA).

A total of 3036 participants aged 6 years (71.8% of the original 2004 cohort), 3027 aged 18 years (57.7% of the original 1993 cohort) and 2417 aged 30 years (40.9% of the original 1982 cohort) had full information on GA and air-displacement plethysmography and were entered in the current analyses. By the time of childbirth, most of the mothers were between 20 and 34 years old and had less than nine years of formal education (Table 1). Prevalence of maternal obesity was 10.0%, 4.8% and 4.3%, and the prevalence of maternal smoking in pregnancy was 27.5%, 33.4% and 35.6%, respectively at the 2004, 1993 and 1982 cohort. Prevalence of low birth weight (LBW; birth weight < 2,500 g) was 10.0% in 2004, 9.8% in 1993, and 9.0% in 1982; and prevalence of preterm birth was 15.6%, 10.8% and 7.0%, respectively (Table 1). Unknown GA accounted for 0.3%, 1.5%, and 21.0% at the 2004, 1993 and 1982 cohorts, respectively.

Table 1 also shows the comparison between the cohort members included in the current analyses and all the participants at the inception of the cohort. For the three cohorts, losses were higher among the poorest and among those with LBW. At the 2004 cohort, losses were higher among children born preterm, whereas at the 1993 cohort, the proportion of losses was higher in those born at term. At the 1993 and 1982 cohort, losses were greater among participants of non-white skin color, born to less educated mothers who smoked during pregnancy.

Table 2 presents the mean and SD of FM, %FM, FMI, and BMI or BMI Z-score, according to GA and sex. In childhood (2004 cohort), all body fat indicators and BMI Z-score were lower in preterm children, in comparison to those born at term, both in boys and girls. In the 1993 cohort, there was no statistical difference between preterm and those born at
term for all outcome indicators either in male or female participants. At 30 years (1982 cohort), all body fat indicators, except BMI, were greater among male participants born preterm, relative to those born at term. For the women, no association was observed.

Table 3 shows the crude and adjusted results from linear regression for male participants. At 6 years, in adjusted analyses, the BMI Z-score, %FM and FMI were lower in preterm than in boys born at term. The adjusted BMI Z-score, %FM and FMI were, respectively, -0.48 kg/m^2 (-0.79; -0.16), -2.91 percentage points (-4.45; -1.36), -0.70 kg/m^2 (-1.13; -0.28) lower in preterm boys born at 34-36 weeks of GA than among those born at term. At the 1993 cohort, no association was found between GA and body fat indicators or BMI in adolescent males (Table 3). At 30 years, after controlling for confounders, mean FM (15.60 kg), %FM (13.65 percentage points) and FMI (5.30 kg/m^2) were greater in men born at ≤33 weeks of gestation than in those born at term (Table 3).

The association of prematurity with body fat indicators and BMI among females at 6, 18, and 30 years old is displayed in Table 4. There was no difference in any of the outcomes at any age for women.

The complementary analyses showed that at 4 years, in the 2004 cohort, BMI Z-scores increased with GA increase for both boys and girls. At 3 years, in the 1982 cohort, BMI Z-scores increased with the increase of GA only in girls. At the three cohorts, there was no association between GA and BMI Z-scores in adjusted analyses (Supplemental table).

**Discussion**

The present study investigated the association of prematurity to body fat and BMI at childhood, adolescence, and adulthood in three different cohorts. In childhood, in crude analyses, preterm boys and girls presented lower FM, %FM, FMI and BMI Z-score when compared to those born at term. In adulthood, an inverse association was observed among men, with higher FM, %FM and FMI in those born preterm than in men born at term. In adjusted analyses, %FM and FMI and BMI Z-score remained lower among 6-year-old boys born at 34-36 weeks of GA. At 30 years, there was no statistical difference in all indicators, although men born at £33 weeks of GA presented higher FM, %FM and FMI. No association between preterm birth and body fat indicators or BMI was observed in female participants at any age at the three cohorts nor in adolescent males (1993 cohort).

The plausibility of the association between preterm birth and less body fat in childhood relies in the fact that energy (fat and glycogen) and nutrient storage in the fetus occur mainly in the last trimester of gestation, thus leading to low energy and nutrient reserve in preterm newborns.(36, 37) Preterm newborns also grow differently in the first months of life with weight loss being inversely proportional to GA and directly proportional to the duration of clinical intercurrences and intrauterine nutritional restriction.(18) Additionally, preterm infants have difficulty to absorb fatty acids due to functional immaturity of the gastrointestinal tract.(38)

Our findings in the 2004 cohort (6 years) suggest that the reduced fat content at birth persists throughout childhood, a result that is consistent with data from children aged 8-12 years in the United Kingdom (39), in which boys and girls born preterm were lighter and had lower FM than those born at term. On the other hand, Piemontese et al. (18) and Johnson et al. (40) showed that infants born preterm had significantly greater total body fat in term equivalent age, and Scheurer et al. (41) reported no association between prematurity (< 35 weeks of GA) and body fat at four years of age in both sexes.

Other factors may play a role on the child body composition, such as maternal complications (like gestational hypertension and gestational diabetes), errors in the estimation of GA, poor-quality or late ultrasound evaluations
(contributing to the physician's decision to induce or not to try tocolysis, or to perform a caesarean section before the completion of pregnancy), and elective C-section. The GA can be overestimated up to 1.8 weeks by inaccurate ultrasound as described elsewhere. The prevalence of C-section in the 2004 cohort (45.2%) almost doubled in relation to the 1982 cohort (27.7%). Although the information on elective C-sections is very difficult to obtain from hospital records because physicians are reluctant to admit that the operation did not have a medical indication the causes of prematurity in 2004 could be due to the medicalization of childbirth and not to biological factors. Thus, the association between GA and body composition in childhood observed in the 2004 cohort could be due to the result of a cohort effect rather than a biological effect of GA. However, the complementary analyses showed that the association between GA and BMI Z-score observed in the 2004 cohort at 6 years was also present among females at 3 years of age in the 1982 cohort, thus indicating that the association was due to GA and not due to a cohort effect.

We found no association between prematurity and body fat among adolescents from the 1993 cohort. Similarly, a study carried out in Spain evaluated the body composition in childhood and adolescence using Dual-energy X-ray absorptiometry and found no difference between those born preterm compared to those born at term. Similarly, Kaczmarczy et al. in the United States evaluated body composition using electrical bioimpedance in adolescent girls (10-14 years) and did not detect any difference between those born preterm or at term.

Although the results from the 1982 cohort (30 years) were not statistically different, adjusted analyses for male (FM, %FM and FMI) pointed out to higher body fat content in those born at ≤33 weeks of GA than in those born at term. These results are consistent with other studies conducted in the United States, United Kingdom and Holland that found increased total body fat and higher abdominal fat among those born preterm. Mathai et al. in New Zealand reported that total body fat, truncal body fat and the android-to-gynoid fat ratio at 30 years were higher among those born at a mean of 33.3 weeks of GA, in comparison to those born at term. Additionally, at that cohort, 5-10 years old term offspring of preterm cohort participants tended to have more body fat, higher truncal fat and android-to-gynoid fat ratio than term offspring from term cohort participants, thus suggesting that negative consequences of preterm birth over body composition may extend to the subsequent generation.

In our study, the interaction between GA and sex over body fat indicators at age 30 years may explain the observed association among men and the lack of association among the women at the three cohorts. There is evidence that exposure to exogenous and endogenous changes during specific windows of developmental programming may affect the susceptibility to non-communicable diseases of the offspring with a difference between males and females regarding the age of onset and severity of disease outcomes.

This study has strengths and limitations. The strengths include the large sample size of three population-based birth cohorts at three different stages of life (childhood, adolescence and adulthood) in a setting where preterm births and excessive weight rates in the population are high. Besides of having three indirect body fat indicators (FM, %FM and FMI) obtained by air-displacement plethysmography, we also evaluated the double-indirect indicator BMI, aiming to facilitate comparability with other studies and communication of our findings. Moreover, all data were collected by employing standardized methods by trained field workers. Finally, we were able to use prospectively measured variables from early life to adjust for confounding effect.

Due to temporal trends and more interventionist medicine over the years an increase on preterm birth prevalence over 22 years (from 1982 to 2004) was registered in Pelotas. Despite this, the role of the method for the assessment of GA must be considered when interpreting our findings. In 1982, only the date of the last menstrual period was used for determining GA, whereas for both 1993 and 2004, the algorithm proposed by the NCHS was
used. Then, the prevalence of preterm birth in 1982 was probably underestimated, and it is highly likely that at least some 30-year-old men of unknown GA belonged to the preterm group, thus affecting the precision of our estimates. Also, because plethysmography was not available in our laboratory before the year 2010, it was not possible to assess body composition at similar ages in the three cohorts.

Conclusions

As a conclusion, preterm birth showed to be associated with body fat in males but not in females. Preterm boys born at 34-36 weeks of GA have lower fat mass at 6 years. Given the large number of preterm infants born each year, it is necessary to prevent risk factors for prematurity to avoid its negative impact over health in adulthood, especially in men, as there are possible links between body composition and the risk of diseases later in life.

List Of Abbreviations

DoHaD: Developmental Origins of Health and Disease; GA: Gestational age; NCHS: National Center for Health Statistics; FM: fat mass in kilograms; %FM: percentage of fat mass; FMI: fat mass index in kg/m²; BMI: body mass index in kg/m² at age 18 and 30 years, and BMI Z-score at 6 years; WHO: World Health Organization; SD: standard deviation; 95%CI: 95% confidence intervals.

Declarations

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All participants of the 1982, 1993 and 2004 Pelotas Birth Cohorts, and colleagues who contributed to the study included since its 1st year.

Author’s contributions

ISS, AM, AJDB and FB contributed to the conception and design of the study. CCB run the statistical analyses and wrote the first draft of the paper. All authors contributed with interpretation of results, approved the final version of the manuscript, and are responsible for all aspects, including ensuring its accuracy and integrity.

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Availability of data and materials
The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

**Consent for publication**

Not applicable

**Competing interests**

The authors declare that they have no competing interest.

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**References**

1. Lawn JE, Gravett MG, Nunes TM, Rubens CE, Stanton C, GAPPS Review Group. Global report on preterm birth and stillbirth (1 of 7): definitions, description of the burden and opportunities to improve data. BMC Pregnancy and Child Birth. 2010;10, Suppl. S1.
2. Victora CG, Aquino EM, do Carmo LM, Monteiro CA, Barros FC, Szwarcwald CL. Maternal and child health in Brazil: progress and challenges. Lancet. 2011;377:1863-1876.
3. Goldani MZ, Barbieri MA, Rona RJ, da Silva AAM, Bettiol, H. Increasing pre-term and low-birth-weight rates over time and their impact on infant mortality in south-east Brazil. J Biosoc Sci. 2004;36:177-188.
4. Barros AJ, Santos LP, Wehrmeister F, Motta JVS, Matijasevich A, Santos IS, et al. Caesarean section and adiposity at 6, 18 and 30 years of age: results from three Pelotas (Brazil) birth cohorts. BMC Public Health. 2017;17:256.
5. World Health Organization (2012). Born too soon: the global action report on preterm birth. WHO Technical Report. Geneva, 2012.
6. Liu L, Oza S, Hogan D, Chu Y, Perin J, Zhu J, et al. Global, regional, and national causes of under-5 mortality in 2000–15: an updated systematic analysis with implications for the Sustainable Development Goals. Lancet. 2016;388:3027-3035
7. Raju TNK. The problem of late-preterm (near-term) births: a workshop summary. Pediatr Res. 2006;6:775.
8. Santos IS, Matijasevich A, Silveira MF, Sclowitz IK, Barros AJ, Victora C. Associated factors and consequences of late preterm births: results from the 2004 Pelotas birth cohort. Paediatr Perinat Epidemiol. 2008;22:350-359.
9. Santos IS, Matijasevich A, Domingues MR, Barros AJ, Victora CG, Barros, FC. Late preterm birth is a risk factor for growth faltering in early childhood: a cohort study. BMC Pediatrics. 2009;16:Suppl. 9:71.
10. Blencowe H, Cousens S, Oestergaard MZ, Chou D, Moller AB, Narwal, R, et al. National, regional, and worldwide estimates of preterm birth rates in the year 2010 with time trends since 1990 for selected countries: a systematic analysis and implications. Lancet. 2012;379:2162-2172.
11. Silveira MF, Santos IS, Barros AJ, Matijasevich A, Barros FC, Victora, CG, et al. Increase in preterm births in Brazil: review of population-based studies. Rev Saude Publica. 2008;42:957–64.
12. Barker, DJ, Osmond, C. Infant mortality, childhood nutrition, and ischemic heart disease in England and Wales. Lancet. 1986;10:1077-81.
13. Butte NF, Hopkinson JM, Wong WW, Wong WW, Smith EOB, Ellis, K. J.. Body composition during the first 2 years of life: an updated reference. Pediatr Res. 2000;47:578.
14. World Health Organization (2011). Global status report of noncommunicable diseases 2010. Geneva: WHO.
15. Piemontese P, Liotto N, Garbarino F, Mornioli D, Taroni F, Bracco B, et al. Effect of prematurity on fat mass distribution and blood pressure at prepubertal age: a follow-up study. Pediatr Med Chi. 2013;35, Suppl.4:166-171.
16. Hui LL, Lam HS, Leung GM, Schooling CM. Late prematurity and adiposity in adolescents: Evidence from “Children of 1997” birth cohort. Obesity. 2015;23 (11):2309-2314.
17. Kaczmarszyk K, Pituch-Zdanowska A, Wiszomirski I, Magiera A, Ronikier A. Long-term effects of premature birth on somatic development in women through adolescence and adulthood. J Int Med Res. 2018;46:44-53.
18. Instituto Brasileiro de Geografia e Estatística (2010) 2010 Census. IBGE. http://www.ibge.gov.br/english/estatistica/populacao/censo2010/default.shtm. Accessed 16 Sep 2020.
19. Gonçalves H, Assunção MC, Wehrmeister FC, Oliveira I, Barros FC, Victora C, et al. Cohort profile update: the 1993 Pelotas (Brazil) birth cohort follow-up visits in adolescence. Int J Epidemiol. 214;43:1082-1088.
20. Santos IS, Barros AJ, Matijasevich A, Zanini R, Cesar MAC, Camargo-Figuera FA, et al. Cohort profile update: 2004 Pelotas (Brazil) Birth Cohort Study. Body composition, mental health and genetic assessment at the 6 years follow-up. Int J Epidemiol. 2014;43:1437-1437a.
21. Dubowitz LM, Dubowitz V, Golberg C Clinical assessment of gestational age in the newborn infant. J Pediatr. 1970;77:1-10.
22. World Health Organization (2006). Child Growth Standards: Length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age. Methods and development WHO, Geneva WHO non-serial publication.
23. Dempster P, Aitkens S. A new air displacement method for the determination of human body composition. Med Sci Sports Exerc. 1995;27:1692–1697.
24. Heymsfield SB, Lohman T, Wang Z, Going SB. (2005). Human Body Composition (Human Kinetics, Champaign, IL)
25. Wells JC, Haroun D, Williams JE, Darch JE, Eaton S, Viner R, et al. Evaluation of lean tissue density for use in air displacement plethysmography in obese children and adolescents. Eur J Clin Nutr. 2011;65:1094.
26. Monteiro JP, Camelo Júnior JS, Vannucchi H (2007). Caminhos da Nutrição e Terapia Nutricional: da concepção à adolescência. Rio de Janeiro: Guanabara Koogan.
27. Gonçalves, A. B (2005). Feeding the preterm newborn. In.: Feferbaum, Rubens; Falcão, M. C. Newborn nutrition. São Paulo: Atheneu.
28. Georgieff MK (1999). Chapter 23. Nutrition. Avery GB, Fletcher MA, MacDonald M. G.eds. Neonatology: Pathophysiology and Management of the Newborn 5th ed., pp. 363–394 Lippincott, Williams Wilkins Philadelphia, PA.
29. Scheurer JM, Zhang L, Gray HL, Weir K, Demerath E. Body composition trajectories from infancy to preschool in children born premature versus full-term. J Pediatr Gastroenterol Nutr. 2017;64:e147-e153.
30. Barros FC, Victora CG, Barros AJ, Santos IS, Albernaz E, Matijasevich A, et al. The challenge of reducing neonatal mortality in middle-income countries: findings from three Brazilian birth cohorts in 1982, 1993, and 2004. The Lancet. 2005;365(9462):847-854.

31. Cesar JA, Matijasevich A, Santos IS, Barros AJ, Dias-da-Costa JS, Barros FC, et al. The use of maternal and child health services in three population-based cohorts in Southern Brazil, 1982-2004. Cad Saúde Pública. 2008;24:s427-s436.

32. Santos IS, Barros AJ, Matijasevich A, Tomasi E, Medeiros RS, Domingues, M. R, et al. Mothers and their pregnancies: a comparison of three population-based cohorts in Southern Brazil. Cad Saúde Pública. 2008;24:s381-s389.

33. Zubillaga DM, Fernández CR, Fernández LR, de Paz Fernandez JA, Franco SA, Patiño FA. Evaluation of isometric force in lower limbs and body composition in preterm infants. Anales de Pediatría (English Edition). 2015;83:229-235.

34. Yeung MY. Postnatal growth, neurodevelopment and altered adiposity after preterm birth--from a clinical nutrition perspective. Acta Paediatr. 2006;95:909-917.

Tables

Table 1. Characteristics of mothers and participants of The Pelotas 2004, 1993 and 1982 Birth Cohorts.
| Characteristics                          | 2004 Cohort | 1993 Cohort | 1982 Cohort |
|-----------------------------------------|-------------|-------------|-------------|
|                                         | Original data at birth | Included in the current analyses | Original data at birth | Included in the current analyses | Original data at birth | Included in the current analyses |
|                                         | N=4231 | N=3036 | N=5249 | N=3027 | N=5914 | N=2417 |
| Maternal education (full years)         | p=0.059² | p<0.001² | p<0.001² | p<0.001²²³ |
| 0 to 4                                  | 654 (15.6) | 445 (14.8) | 1468 (28.0) | 758 (25.1) | 1960 (33.2) | 685 (24.4) |
| 5 to 8                                  | 1731 (41.4) | 1255 (41.7) | 2424 (46.2) | 1427 (47.2) | 2454 (41.5) | 1065 (44.1) |
| 9 to 11                                 | 1381 (33.0) | 1015 (33.7) | 923 (17.6) | 573 (19.0) | 654 (11.1) | 278 (11.5) |
| ≥12                                     | 420 (10.0) | 295 (9.8) | 427 (8.2) | 264 (8.7) | 839 (14.2) | 388 (16.1) |
| Maternal age                            | p=0.134² | p=0.056² | p=0.001² | p<0.001²²³ |
| <20                                     | 799 (18.9) | 580 (19.1) | 915 (17.4) | 509 (16.8) | 912 (15.4) | 327 (13.5) |
| 20 to 34                                | 2865 (67.8) | 2033 (67.0) | 3756 (71.6) | 2161 (71.4) | 4415 (74.7) | 1836 (76.0) |
| ≥35                                     | 563 (13.3) | 422 (13.9) | 577 (11.0) | 357 (11.8) | 586 (9.9) | 254 (10.5) |
| Pre-gestational BMI¹                    | p=0.003² | p=0.267² | p=0.374² | p<0.001²²³ |
| Underweight (≤18.49 kg/m²)              | 599 (20.2) | 405 (18.9) | 451 (8.9) | 259 (8.7) | 388 (7.8) | 152 (7.2) |
| Adequate (18.5-24.9 kg/m²)              | 1422 (47.8) | 1023 (56.9) | 3521 (69.1) | 2040 (68.5) | 3498 (70.3) | 1492 (70.1) |
| Overweight (25.0-29.9 kg/m²)            | 652 (22.0) | 503 (28.0) | 880 (17.3) | 540 (18.1) | 875 (17.6) | 390 (18.3) |
| Obesity (≥30 kg/m²)                     | 297 (10.0) | 214 (11.9) | 245 (4.8) | 139 (4.7) | 215 (4.3) | 94 (4.4) |
| Maternal smoking during pregnancy       | p=0.530² | p=0.003² | p<0.001² | p<0.001²²³ |
| No                                      | 3067 (72.5) | 2210 (72.8) | 3497 (66.6) | 2066 (68.3) | 3811 (64.4) | 1623 (67.2) |
| Yes                                     | 1162 | 826 (28.0) | 1752 | 961 (31.8) | 2103 | 794 (32.9) |
| Family income at birth (tertiles) | p=0.010 | p<0.001 | p<0.001 | p<0.001 |
|----------------------------------|----------|----------|----------|----------|
| 1º (poorest)                    | 1429 (33.7) | 986 (32.5) | 2226 (43.3) | 1233 (41.0) | 1963 (33.2) | 688 (28.5) |
| 2º                              | 1404 (33.2) | 1039 (34.2) | 1445 (28.2) | 861 (28.9) | 1979 (33.5) | 861 (35.7) |
| 3º (wealthiest)                 | 1396 (33.1) | 1011 (33.3) | 1466 (28.5) | 899 (30.1) | 1972 (33.3) | 868 (35.9) |

| Participants characteristics |
|--------------------------------|
| Sex                           |
| Male                          | p=0.450 | p=0.553 | p=0.253 | p=0.447 |
| Male                          | 2195 (51.9) | 1564 (51.5) | 2603 (49.6) | 1512 (49.9) | 3037 (51.4) | 1216 (50.3) |
| Female                        | 2036 (48.1) | 1472 (48.5) | 2645 (50.4) | 1515 (50.1) | 2876 (48.6) | 1201 (49.7) |
| Skin color                    | p=0.807 | p=0.040 | p<0.001 | p<0.001 |
| White                         | 2726 (68.2) | 2067 (68.1) | 2769 (64.1) | 1893 (65.1) | 3238 (75.4) | 1678 (76.0) |
| Non-white                     | 1272 (31.8) | 969 (31.9) | 1554 (36.0) | 1015 (34.9) | 1058 (24.6) | 531 (24.0) |
| Birth weight (g)              |
| p=0.001 | p<0.001 | p=0.019 | p<0.001 |
| <2.500                         | 423 (10.0) | 234 (7.7) | 510 (9.8) | 221 (7.3) | 534 (9.0) | 124 (5.1) |
| 2.500-2.999                    | 1042 (24.7) | 747 (24.6) | 1311 (25.1) | 754 (24.9) | 1393 (23.6) | 559 (23.1) |
| 3.000-3.499                    | 1651 (39.0) | 1206 (39.7) | 2020 (39.0) | 1206 (39.9) | 2200 (37.6) | 933 (38.6) |
| 3.500-3.999                    | 912 (21.6) | 700 (23.1) | 1081 (20.7) | 684 (22.6) | 1417 (24.0) | 649 (26.9) |
| ≥4.000                         | 198 (4.7) | 149 (4.9) | 280 (5.4) | 161 (5.3) | 345 (5.8) | 152 (6.3) |
| Gestational age (weeks)        |
| p=0.001 | p<0.001 | p=0.029 | p<0.001 |
| ≤33                            | 140 (3.6) | 68 (2.2) | 143 (3.4) | 74 (2.4) | 49 (1.2) | 9 (0.4) |
| 34-36                           | 472 (12.0) | 332 (10.9) | 429 (10.2) | 276 (9.1) | 245 (5.8) | 119 (4.9) |
| 37-41                           | 3336 | 2636 (86.8) | 3637 | 2677 (88.5) | 3909 | 2289 (94.7) |
(84.5)  (86.4)  (93.0)

1 BMI, body mass index. 2 P-values calculated by Chi-square test. 3 P-values indicating the difference between the 3 cohorts

**Table 2.** Means and standard deviations of body fat indicators according to gestational age.
| Gestational age | Total N | Male | Female |
|-----------------|---------|------|--------|
|                 | FM (kg) | FM (%) | FMI (kg/m²) | BMI¹ (kg/m²) | FM (kg) | FM (%) | FMI (kg/m²) | BMI¹ (kg/m²) |
| 6 y (2004 Cohort) | N | Mean (SD)² | Mean (SD)² | Mean (SD)² | Mean (SD)² | Mean (SD)² | Mean (SD)² | Mean (SD)² | Mean (SD)² | Mean (SD)² | Mean (SD)² | Mean (SD)² | Mean (SD)² |
| ≤33             | 68     | 4.8 (3.3) | 19.8 (6.8) | 3.2 (1.8) | 0.05 (1.5) | 5.8 (3.1) | 23.9 (7.1) | 4.1 (1.8) | 0.51 (1.2) | 5.8 (3.1) | 23.9 (7.1) | 4.1 (1.8) | 0.51 (1.2) |
| 34 to 36        | 332    | 5.1 (3.7) | 20.2 (7.4) | 3.4 (2.1) | 0.21 (1.6) | 5.7 (3.2) | 23.2 (7.2) | 3.9 (1.9) | 0.40 (1.2) | 5.7 (3.2) | 23.2 (7.2) | 3.9 (1.9) | 0.40 (1.2) |
| 37 to 41        | 2636   | 6.1 (3.6) | 22.5 (7.9) | 4.0 (2.1) | 0.81 (1.5) | 6.8 (4.0) | 25.5 (8.0) | 4.6 (2.4) | 0.72 (1.4) | 6.8 (4.0) | 25.5 (8.0) | 4.6 (2.4) | 0.72 (1.4) |
| Total           | 3036   | 5.9 (3.6) | 22.2 (7.9) | 3.9 (2.1) | 0.72 (1.5) | 6.6 (3.8) | 25.2 (7.9) | 4.5 (2.3) | 0.67 (1.4) | 6.6 (3.8) | 25.2 (7.9) | 4.5 (2.3) | 0.67 (1.4) |
| 18 y (1993 Cohort) | N | Mean (SD)² | Mean (SD)² | Mean (SD)² | Mean (SD)² | Mean (SD)² | Mean (SD)² | Mean (SD)² | Mean (SD)² | Mean (SD)² | Mean (SD)² | Mean (SD)² | Mean (SD)² |
| ≤33             | 74     | 12.6 (13.4) | 15.7 (10.5) | 4.4 (4.5) | 23.4 (5.7) | 19.6 (9.5) | 31.4 (8.4) | 7.6 (3.5) | 23.1 (4.7) |
| 34 to 36        | 276    | 12.5 (10.0) | 16.5 (9.1) | 4.1 (3.2) | 23.2 (4.3) | 20.9 (8.7) | 32.7 (7.8) | 8.1 (3.4) | 23.7 (4.6) |
| 37 to 41        | 2677   | 12.9 (9.5) | 16.8 (8.8) | 4.2 (3.1) | 23.4 (4.2) | 20.9 (9.6) | 32.8 (7.9) | 8.0 (3.6) | 25.5 (4.9) |
| Total           | 3027   | 12.7 (9.6) | 16.6 (8.8) | 4.2 (3.1) | 23.3 (4.2) | 20.8 (9.4) | 32.7 (7.8) | 8.0 (3.6) | 23.5 (4.8) |
| 30 y (1982 Cohort) | N | Mean (SD)² | Mean (SD)² | Mean (SD)² | Mean (SD)² | Mean (SD)² | Mean (SD)² | Mean (SD)² | Mean (SD)² | Mean (SD)² | Mean (SD)² | Mean (SD)² | Mean (SD)² |
| ≤33             | 9      | 34.9 (5.6) | 37.7 (2.6) | 11.6 (1.6) | 30.7 (2.6) | 23.2 (6.0) | 37.2 (3.8) | 9.1 (2.0) | 26.6 (5.9) |
| 34 to 36        | 119    | 21.1 (11.0) | 24.4 (9.1) | 7.0 (3.7) | 27.0 (5.0) | 24.3 (10.9) | 35.3 (8.8) | 9.4 (4.3) | 25.4 (5.6) |
| 37 to 41        | 2289   | 21.3 (11.4) | 24.6 (9.0) | 7.0 (3.6) | 27.0 (4.9) | 27.0 (12.0) | 37.3 (8.4) | 10.3 (4.5) | 24.2 (3.4) |
| Total           | 2417   | 21.4 (11.6) | 24.6 (9.2) | 7.0 (3.7) | 27.0 (5.0) | 27.2 (12.2) | 37.4 (8.5) | 10.4 (4.6) | 26.8 (6.0) |

¹BMI, body mass index. ²SD, standard deviation

*At 6 years, BMI in Z-score
Table 3. Association between gestational age and body fat indicators in male participants.

|                      | FM\(^1\) (kg) | %FM\(^2\) | FMI\(^3\) (kg/m\(^2\)) | BMI\(^4,5\) (kg/m\(^2\)) |
|----------------------|---------------|-----------|--------------------------|---------------------------|
|                      | β (CI95%)     | β (CI95%) | β (CI95%)                | β (CI95%)                |
| **Gestational age**  | Crude         | Adjusted  | Crude                    | Adjusted                  |
|                      | Crude         | Adjusted  | Crude                    | Adjusted                  |
|                      | Crude         | Adjusted  | Crude                    | Adjusted                  |
|                      | Crude         | Adjusted  | Crude                    | Adjusted                  |
| 6 y (2004 Cohort)    | p<0.001       | p=0.123   | p<0.001                  | p<0.001                  |
| ≤33                  | -1.29 (1.54; 1.29) | -0.24 (1.80; 1.29) | -2.72 (5.31; 0.14) | -1.82 (4.90; 1.26) |
|                      | -0.76 (1.47; 1.36) | -0.53 (1.36; 0.31) | -0.76 (1.26; 0.31) | -0.24 (0.87; 0.38) |
| 34 to 36             | -0.97 (1.54; -0.39) | -0.82 (0.16; 0.03) | -2.32 (5.31; 0.14) | -2.91 (4.45; 1.36) |
|                      | -2.72 (-5.31; 1.94) | -2.32 (5.31; 0.14) | -1.82 (4.90; 1.26) | -0.76 (0.87; 0.38) |
| 37 to 41             | ref           | ref       | ref                      | ref                       |
| 18 y (1993 Cohort)   | p=0.873       | p=0.469   | p=0.711                  | p=0.318                  |
| ≤33                  | -0.36 (3.75; 3.02) | -1.16 (4.26; 1.94) | -2.72 (5.31; 0.14) | -1.82 (4.90; 1.26) |
|                      | -0.10 (-1.63; 0.44) | -0.76 (-1.26; 0.31) | -0.76 (-1.26; 0.31) | -0.24 (-0.87; 0.38) |
| 34 to 36             | -0.41 (2.08; 1.25) | 0.91 (7.91; 2.61) | 0.91 (7.91; 2.61) | 0.91 (7.91; 2.61) |
|                      | 0.30 (-0.31; 0.91) | 0.30 (-0.31; 0.91) | 0.30 (-0.31; 0.91) | 0.30 (-0.31; 0.91) |
| 37 to 41             | ref           | ref       | ref                      | ref                       |
| 30 y (1982 Cohort)   | p=0.056       | p=0.131   | p=0.014                  | p=0.105                  |
| ≤33                  | 13.62 (2.48; 24.75) | 13.17 (4.33; 22.02) | 13.65 (1.38; 25.92) | 4.62 (1.04; 8.21) |
|                      | 5.30 (0.30; 10.37) | 5.30 (0.30; 10.37) | 5.30 (0.30; 10.37) | 5.30 (0.30; 10.37) |
| 34 to 36             | -0.02 (-3.26; 2.82) | -0.12 (-2.53; 2.30) | -0.03 (-2.56; 2.30) | -0.01 (-0.99; 0.97) |
|                      | 0.26 (0.85; 1.37) | 0.26 (0.85; 1.37) | 0.26 (0.85; 1.37) | 0.26 (0.85; 1.37) |
| 37 to 41             | ref           | ref       | ref                      | ref                       |

\(^1\) FM, fat mass; \(^2\) %FM, percentage of fat mass; \(^3\) FMI, fat mass index; \(^4\) BMI, body mass index.

*At 6 years, BMI in Z-score.

β refers to linear regression models. Models were adjusted for maternal (education, age, family income at birth, smoking during pregnancy, and pre-gestational BMI) and the cohort participant characteristics (birth weight and skin color).
Table 4. Association between gestational age and body fat indicators in female participants.

|                  | FM¹ (kg) | %FM² | FMI³ (kg/m²) | BMI⁴.⁵ (kg/m²) |
|------------------|----------|------|--------------|---------------|
|                  | β (CI95%)| β (CI95%)| β (CI95%)| β (CI95%) |
| **Gestational age** | Crude | Adjusted | Crude | Adjusted | Crude | Adjusted | Crude | Adjusted |
| 6 y (2004 Cohort) | p=0.002 | p=0.825 | p=0.001 | p=0.761 | p=0.003 | p=0.636 | p=0.004 | p=0.604 |
| ≤33              | -1.01    | (2.34; 0.33) | 0.12   | (2.08; 2.32) | -1.54   | (-3.58; -1.02) | -0.22   | (-4.75; 4.31) | -0.44   | (-1.25; 0.37) | -0.01   | (-1.39; 1.37) | -0.21   | (-0.68; 0.27) | 0.17    | (-0.61; 0.94) |
| 34 to 36         | -1.06    | (-1.69; -0.44) | -0.26  | (-1.14; 0.62) | -2.30   | (-4.29; 1.20) | -0.68   | (-2.50; 1.13) | -0.63   | (-1.01; 0.28) | -0.26   | (-0.79; -0.10) | -0.32   | (-0.54; 0.22) | -0.08   | (-0.38; 0.22) |
| 37 to 41         | ref      | ref      | ref    | ref      | ref    | ref      | ref    | ref      |
| 18 y (1993 Cohort) | p=0.666 | p=0.545 | p=0.519 | p=0.473 | p=0.710 | p=0.520 | p=0.746 | p=0.433 |
| ≤33              | -1.34    | (-4.27; 1.58) | -0.29  | (-3.26; 2.68) | -1.41   | (-3.83; 1.01) | -0.99   | (-3.63; 1.66) | -0.47   | (-1.58; 0.65) | -0.35   | (-1.44; 0.74) | -0.40   | (-1.89; 1.09) | -0.24   | (-1.65; 1.16) |
| 34 to 36         | -0.05    | (-1.74; 1.65) | 0.92   | (0.78; 2.63) | -0.13   | (-1.53; 1.28) | 0.63    | (-0.75; 2.02) | 0.02    | (-0.63; 0.66) | 0.28    | (-0.34; 0.89) | 0.23    | (-0.63; 1.10) | 0.49    | (-0.31; 1.28) |
| 37 to 41         | ref      | ref      | ref    | ref      | ref    | ref      | ref    | ref      |
| 30 y (1982 Cohort) | p=0.164 | p=0.640 | p=0.203 | p=0.414 | p=0.249 | p=0.402 | p=0.208 | p=0.158 |
| ≤33              | -3.81    | (-14.27; 6.65) | 0.91   | (-11.24; 9.42) | -0.12   | (-7.54; 7.30) | 0.43    | (-6.68; 7.53) | -1.27   | (-5.25; 2.71) | -0.97   | (-4.79; 2.85) | -2.44   | (-7.61; 2.74) | -2.26   | (-7.24; 2.72) |
| 34 to 36         | -2.74    | (-5.76; 0.29) | -1.54  | (-4.77; 1.68) | -1.95   | (-4.09; 0.19) | -1.48   | (-3.67; 0.72) | -0.91   | (-2.06; 0.24) | -0.76   | (-1.94; 0.42) | -1.16   | (-2.66; 0.33) | -1.44   | (-3.08; 0.20) |
| 37 to 41         | ref      | ref      | ref    | ref      | ref    | ref      | ref    | ref      |

¹ FM, fat mass; ² %FM, percentage of fat mass; ³ FMI, fat mass index; ⁴ BMI, body mass index.

* At 6 years, BMI in Z-score.

β refers to linear regression models. Models were adjusted for maternal (education, age, family income at birth, smoking during pregnancy, and pre-gestational BMI) and cohort participant characteristics (birth weight and skin color)