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Gestational weight gain and macrosomia in a cohort of mothers and their children

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Abstract

Objective: To identify co-variables potentially associated to infant macrosomia, including excessive gestational weight gain.

Methods: A cohort was investigated consisting of 230 pairs of mothers and children, residents of the City of Rio de Janeiro. Fetal macrosomia, defined as a birth weight ≥ 4,000 grams was treated as the dependent variable. Statistical analysis of the relation between macrosomia and co-variables involved stratified analysis and multivariate logistic regression, which estimates odds ratios (OR) and 95% confidence intervals (CI 95%).

Results: The incidence of excessive gestational weight gain was 29.1%, varying from 10% for women under 20 years to 63.6% for women who had given birth to children with macrosomia. Macrosomia incidence was 4.8% for the group as a whole, 10.4% for women with excessive gestational weight gain and 2.5% for women with normal gestational weight gain. Women with excessive gestational weight gain and ≥ 20 years exhibited a chance of developing macrosomia that was 5.42 times greater (CI 95%: 1.11 - 26.34). Within the final multivariate logistic regression model, only excessive gestational weight gain (OR = 5.83, CI 95%: 1.51 - 22.48) remained associated to infant macrosomia.

Conclusions: Considering that excessive gestational weight gain was the only predictor related to macrosomia, it is important that preventive programs that take account of this predictor be implemented, avoiding undesirable fetal outcomes. Future studies should include a wider variety of macrosomia predictors and additional birth outcomes.

J Pediatr (Rio J). 2005;81(1):47-53: Fetal macrosomia, birth weight, weight gain, pregnancy, obesity, health transition.

Introduction

A number of different studies, both domestic and international, have been undertaken over recent decades with the objective of investigating the determinants, the magnitude and the evolution over time of low birth weight.[1-6] In general, these studies have revealed that insufficient gestational weight gain, low maternal age, short maternal stature and alcohol and tobacco consumption, among other factors, are determinants of low birth weight.

There is consensus in the literature that adequate weight gain during gestation is associated with a satisfactory fetal outcome.[7-9] In general, it is assumed that normal fetal growth is a positive function of gestational weight gain, modified by pre-gestational nutritional status.[10] During the last decade, the Institute of Medicine - IOM,[7] with the objective of optimizing birth weight, made recommendations for weight gain rates to be differentiated according to maternal nutritional status, measured by pre-gestational BMI. Thus, greatest gains should occur among women with low pre-gestational BMI (< 19.8 kg/m^2), with intermediate ones for women with normal pre-gestational BMI (> 19.8 and ≤ 26.0 kg/m^2) and lowest gains among women with pre-gestational BMI defined as overweight (> 26.0 and ≤ 29 kg/m^2) and obese (BMI > 29.0 kg/m^2).[7]

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Recent data on the magnitude of low birth weight in the Brazilian population revealed that the problem continues to have epidemiological relevance and that the magnitude itself is currently stable.[4] In contrast, studies of the pattern of distribution and of the determinants of macrossomia remain rare for the Brazilian population.

Recently, certain international studies[11-12] and other domestic ones[13-14] have demonstrated a strict relation between excessive gestational weight gain and macrossomia. The definition of macrossomia is still under debate, but, in general, it has been defined as birth weight values $\geq$ 4,000 g, $\geq$ 4,500 g or as values for birth weight above the 90th percentile of a reference curve for gestational age and sex.[15] The occurrence of macrossomia has been associated with an increased risk of caesarians, trauma during labor and infant morbidity, in particular when it is associated with gestational diabetes.[11] The principal determinants of macrossomia include advanced maternal age, multiparity and pre-gestational obesity, in addition to excessive gestational weight.[16]

Against this background, the objective of the present study consists of evaluating the association between excessive gestational weight gain, according to the IOM's recommendations, and macrossomia, based on data obtained from a cohort of mothers and their children, followed-up for 9 months postpartum.

Methods

Four hundred and seventy-nine women were enrolled and followed for 9 months postpartum in a cohort study undertaken in the city of Rio de Janeiro, between May 1999 and April 2001. Observations were made in four waves, at approximately 15 days and at 2, 6 and 9 months. It was at these points that anthropometric data and all co-variables were collected. Women were recruited from three different locations, namely, at the area's central maternity hospital, during the prenatal routine, and during routine BCG immunization; these last two locations are within the Marcolino Candau municipal health center.

The eligibility criteria established for the cohort were: aged 15 to 45 years, first interviewed less than 30 days postpartum, free of chronic diseases, a gestational age of more than 35 weeks at birth, single birth and resident within the study area.

The pattern of losses was evaluated in terms of the distribution of final study completion rates [number of women completing the study/number of women enrolled into the cohort] with respect of a number of important co-variables. Differences in final follow-up rates were evaluated using the chi-square test for proportions. Additional details of cohort recruitment, inclusion of participants, exclusion criteria, anthropometric data collection and the pattern of losses can be obtained from previous publications.[17-21]

Macrossomia (birth weight $\geq$ 4,000 grams) was defined as the dependent variable. Birth weight was provided by the mother at the first interview and the value given was checked against the baby's records whenever available. The consistency of the birth weight variable was tested against the weight values obtained at the first observation, with no inconsistent values being identified; i.e., observed values for birth weight were always lower than those obtained during the first wave of observations.

The following co-variables were included in the analysis: sex of child (male, female), age of mother ($<$ 20, $\geq$ 20 years), mother's skin color (white, mulatto, black), marital status (married, with partner, single), education ($<$ 8, $\geq$ 8 years' schooling), total family income ($<$ 500, $\geq$ 500 Reais), previous caesarian delivery (no, yes), previous abortion (no, yes), parity (1, $\geq$ 2 children), age of mother at birth of first child ($<$ 17, $\geq$ 17 years) and gestational age at birth ($<$ 41, $\geq$ 41 weeks). Skin color was based on the interviewer's observations and gestational age calculated based on the date of last menstruation (DLM). This information was obtained during the second wave of observations and has been used systematically to estimate gestational age in the absence of ultrasound.[22] Pre-gestational Body Mass Index [weight (kg)/stature $(m)^2$] was obtained during the first wave of observations and was calculated from the pre-gestational weight reported by the mother and stature measured with a Harpenden stadiometer (Harpenden Inc.), using standardized techniques.[23]

Gestational weight gain was the study's primary co-variable. The variable was reported by the mother during the third observation wave, at 6 months postpartum and was analyzed according to the weight gain categories recommended by the Institute of Medicine.[7] The IOM recommend weight gain rates that are differentiated according to pre-gestational nutritional status, measured by body mass index. Gains in weight of more than 18 kg, were considered excessive for women with pre-gestational BMI $<$ 19.8 kg/m^2, gains over 16kg for women with pre-gestational BMI between 19.8 and 26 kg/m^2, greater than 11.5 kg, for women with pre-gestational BMI $>$ 26 and $\leq$ 29 kg/m^2 and gains $\geq$ 6 kg were considered excessive for women whose pre-gestational BMI had been $>$ 29 kg/m^2. Because data for gestational weight gain were only obtained during the third wave of follow-up (6 months postpartum), there were losses and only 230 women could be included in the present analysis.

The statistical analysis initially involved testing the differences between the co-variables described above in proportions of excessive weight gain using the chi-square test. Next, the incidence rates of macrossomia were calculated for the overall group of children, according to the selected co-variables, and stratified by excessive gestational weight gain or not. Relative risk ratios (RR) were then calculated in strata, overall, and adjusted for gestational weight, as were their respective 95% confidence intervals (95% CI). The RR values for the strata were compared using the Mantel & Haenzel test. A selection was made of reference categories for the variables taking the lowest incidence of macrossomia into account. Finally, an unconditional logistic regression analysis was performed, controlling for confounding variables with macrossomia as the dependent variable. Variables were included in the final model if they exhibited statistical significance in the bivariate analysis.

The project was submitted to and approved by the Ethics Committee at the Collective Health Studies Nucleus – NESC (*Núcleo de Estudos de Saúde Coletiva*), at the *Universidade Federal do Rio de Janeiro* (UFRJ) and is in compliance with the ethical principles of non-maleficence, beneficence, justice and autonomy, contained in Resolution 196/96 of the National Health Council (*Conselho Nacional de Saúde*).[24] All participants signed a consent form, obtained in a free and spontaneous, once necessary explanations had been made.

All analysis was carried using the computer program SPLUS 2000 (MathSoft). Values for p of less than 0.05 were defined as statistically significant.

Results

Comparative analyses revealed that the incidence of macrossomia and means for birth weight did not differ between the children who participated in the study (n = 230) and those considered as losses or those for whom mothers did not have data for gestational weight gain available (n = 175) (results not shown). Table 1 shows data for the final rate of follow-up according to a number of different important study variables. It can be observed that the pattern of losses is random since for all of the variables tested chi-square for proportions was greater than 0.05.

Of the 230 women studied, 29.1% presented excessive gestational weight gain, 34.4% normal gestational weight gain and 36.5% gestational weight gain below that recommended by the IOM. Table 2 contains data on the frequency of excessive gestational weight gain according to selected variables. The greater incidence rates of excessive gestational weight gain were observed among married women (35.8%), those whose age at first birth was < 17 years (36.6%), with gestational age ≥ 41 weeks (38.1%) and with birth weights ≥ 4,000 grams (63.6%). No statistically significant differences were observed in the incidence of excessive gestational weight gain between the various variable categories chosen, with the exception of birth weight ≥ 4,000 grams.

Table 3 contains data for the incidence rates of macrossomia for the group of children as a whole and stratified by excessive and normal gestational weight gain and by selected variables. The general incidence of macrossomia was 4.8%, with rates of 10.4% for the children of women with excessive gestational weight gain and 2.5% for the children of women with normal gestational weight gain. The greatest macrossomia incidence rates were observed among the children of women with excessive gestational weight gain and ages ≥ 20 years (50.0%), with total family incomes ≥ 500 Reais (15.2%) and among children born with gestational ages ≥ 41 weeks (18.8%).

Table 1 - Distribution of frequency for the selected variables for losses, complete follow-up and final rate of follow-up (Rio de Janeiro, 1991-2001)

Variables	Initial number of observation	Follow-up losses n	Complete follow-up	Final rate of follow-up %	p
Age group (years)					
18-24	196	95	101	51.5	
25-29	114	47	67	58.7	
30-45	95	33	62	65.3	0.0753
Marital status					
Single	74	25	49	66.2	
Partner	230	102	128	55.6	
Married	101	48	53	52.5	0.1680
Skin color					
White	154	59	95	61.7	
Mulatto	179	79	100	55.9	
Black	72	37	35	48.6	0.1711
Child's sex					
Male	199	88	111	55.8	
Female	206	87	119	57.8	0.6863
Pre-gestational BMI (kg/m²)					
< 19.8	85	39	46	54.1	
19.8-26.0	249	103	146	58.6	
26.1-29.0	47	23	24	51.1	
> 29.0	24	10	14	58.3	0.7424
Macrossomia					
Yes	20	9	11	55.0	
No	385	166	219	56.9	0.8683

BMI = body mass index.

Table 4 contains figures for relative risk (RR) of macrossomia, stratified, overall and adjusted for gestational weight gain. The chance of having a child with macrossomia was 5.42 (95% CI: 1.11 - 26.34) times greater in women with excessive gestational weight gain and aged 20 years or more. Values for RR did not, however, differ between gestational weight gain strata. Values for RR were not statistically significant for any of the other variables.

Table 2 - Incidence of excessive gestational weight gain according to selected variables (Rio de Janeiro, 1999-2001)

Variables		Gestational weight gain *		
	n	n	%	p
Child's sex				
Male	111	29	26.1	
Female	119	38	31.9	0.4103
Mother's age (years)				
< 20	20	2	10.0	
≥ 20	210	65	31.0	0.0867
Skin color				
White	95	33	34.7	
Mulatto	100	23	23.0	
Black	35	11	31.4	0.1867
Marital status				
Married	53	19	35.8	
Partner	128	37	28.9	
Single	49	11	22.4	0.3293
Educational level (years)				
< 8	102	30	29.4	
≥ 8	128	37	28.9	0.9503
Total family income (reais)				
< 500	113	34	30.1	
≥ 500	117	33	28.2	0.8656
Previous caesarian delivery				
No	143	27	31.0	
Yes	87	40	28.0	0.7292
Previous abortion				
No	153	40	26.1	
Yes	77	27	35.1	0.2107
Parity (number of children)				
1	110	29	26.4	
≥ 2	120	38	31.7	0.4599
Age of mother at birth of first child (years)				
< 17	41	15	36.6	
≥ 17	189	52	27.5	0.3323
Gestational age (weeks)				
< 41	188	51	27.1	
≥ 41	42	16	38.1	0.2200
Birth weight (g)				
< 4,000	219	60	27.4	
≥ 4,000	11	7	63.6	0.0159
Total	230	67	29.1	

* Gestational weight gain classified according to the Institute of Medicine (IOM, 1990).

Results of the final logistic regression model reveal that excessive gestational weight gain was the only statistically significant predictor, being connected with a 5.83 (95% CI: 1.51 - 22.48) times greater chance of developing macrossomia. Maternal age (RR = 4.38, 95% CI: 0.76 - 25.28) was retained in the final model in order to control residual confounding (Table 5).

Discussion

The results of the present study revealed that women with excessive gestational weight gain presented a 5.83 (95% CI: 1.51 - 22.48) times greater chance of giving birth to a child with macrossomia.

Excessive gestational weight gain has been described as being an important risk factor for a series of unfavorable fetal and maternal outcomes.[7,8,20,21] In the present study it was observed that almost a third of the mothers studied exhibited excessive gestational weight gain. These values coincide with figures reported by Nucci et al.[14] for a sample of more than 3,000 women studied at six Brazilian state capitals. The incidence rates of excessive gestational weight gain varied from 10% for mothers less than 20 years old to 63.6% for those who had had children with macrossomia.

The incidence of macrossomia in the present study was just 4.8%. This value could be considered low when compared with Native American populations, where figures reach high values from 16 to 31%,[25-27] or even when compared with the American population in general, which exhibits rates of the order of 10%.[28] Comparisons with European countries such as Germany in 1999 (10.1%)[29] and Denmark in 1999 (20.0%),[30] demonstrate that the values observed here are still low with respect of those populations. In Brazil, studies of the magnitude and even of the determining factors of macrossomia are still rare. The results of one study with 2,275 pairs of mothers and children revealed an incidence of 5.3%,[13] while Nucci et al.[31] despite not reporting figures for frequency, observed a 61% greater risk of macrossomia among women with BMI of between 25.0 and 29.9 kg/m.[2]

Taking the context of nutritional transition into account, it is important to point out that the incidence of macrossomia and its historical tendencies should be considered new and relevant indicators. In this sense it is interesting to observe that the incidence of macrossomia observed in the present study was low. These values place Brazil at an intermediate level in terms of nutritional transition, for which one of the most advanced manifestations is certainly an elevated frequency of macrossomia.[29]

Among the many factors that determine macrossomia, international studies have highlighted multiparity, pre-gestational overweight or obesity, advanced maternal age, prolonged gestation, excessive gestational weight gain and the occurrence of gestational diabetes as being the most important predictors.[11,16,29] All of these potential predictors, with the exception of gestational diabetes were investigated in the present study, however, only excessive gestational weight gain was significantly associated with macrossomia. Maternal age presented a significant risk only when

Table 3 - Incidence rates of macrossomia according to gestational weight gain stratified by the variables selected (Rio de Janeiro, 1999-2001)

Variables	Gestational weight gain *					
	Excessive		Normal		Total	
	n	%	n	%	n	%
Child's sex						
Male	3	10.3	4	4.9	7	6.3
Female	4	10.5	0	0	4	3.4
Mother's age (years)						
≥ 20	1	50.0	1	5.6	2	10.0
< 20	6	9.2	3	2.1	9	4.3
Skin color						
White	4	12.1	2	3.2	6	6.3
Mulatto	3	13.0	2	2.6	5	5.0
Black	0	0	0	0	0	
Marital status						
Married	2	10.5	1	2.9	3	5.7
Partner	5	13.5	2	2.2	7	5.5
Single	0	0	1	2.6	1	2.0
Educational level (years)						
≥ 8	4	10.8	3	3.3	7	5.5
< 8	3	10.0	1	1.4	4	3.9
Total family income (reais)						
≥500	5	15.2	1	1.2	6	5.1
< 500	2	5.9	3	3.8	5	4.4
Previous caesarian delivery						
Yes	4	14.8	2	3.3	6	6.9
No	3	7.5	2	1.9	5	3.5
Previous abortion						
Yes	3	11.1	1	2.0	4	5.2
No	4	10.0	3	2.7	7	4.6
Parity (number of children)						
1	3	10.3	2	2.5	5	4.5
≥ 2	4	10.5	3	2.4	6	5.0
Age of mother at birth of first child (years)						
< 17	1	6.7	1	3.8	2	4.9
≥ 17	3	11.5	6	2.2	9	4.8
Gestational age (weeks)						
≥ 41	3	18.8	1	3.8	4	9.5
< 41	4	7.8	3	2.2	7	3.7
Total	7	10.4	4	2.5	11	4.8

* Gestational weight gain classified according to the Institute of Medicine (IOM, 1990).

unadjusted. For the remaining predictors, no effect was observed from parity or advanced gestational age, although the incidence of macrossomia for women giving birth after ≥ 41 weeks and with excessive gestational weight gain was 18.8%, more than three times greater than the mean global incidence of 4.8%.

Certain limitations of the present study merit discussion. In first place should be considered the significant reduction in observation numbers resulting from follow-up losses, since information on gestational weight gain was only obtained during the third follow-up wave, at 6 months postpartum. Nevertheless, previous analyses of the same population[20] and of others performed for the present study, reveal a pattern of random losses, thus guaranteeing that the 230 women and children analyzed here, are representative of the initial group of 479 pairs of mothers and children. One further limitation is with respect of the fact that data for gestational weight gain were reported by the mothers, which potentially could generate some type of bias. Nevertheless, we believe that the use of this information

Table 4 - Relative risk (RR) of macrossomia, stratified, overall and adjusted for gestational weight gain for the selected variables (Rio de Janeiro, 1999-2001)

Variables †	Gestational weight gain *			
	Excessive	Normal	Overall	Adjusted
	Relative risk (95% CI)			
Child's sex	0.98 (0.24-4.05)	– ‡	1.88 (0.57-6.29)	2.13 (0.62-7.33)
Mother's age (years)	5.42 (1.11-26.34)	2.69 (0.29-24.47)	2.33 (0.52-9.71)	3.64 (0.89-14.85)
Educational level (years)	1.08 (0.26-4.46)	2.37 (0.25-22.3)	1.39 (0.42-4.69)	1.41 (0.43-4.60)
Total family income (reais)	2.58 (0.54-12.36)	0.31 (0.03-2.95)	1.16 (0.37-3.79)	1.19 (0.38-3.73)
Previous caesarian delivery	1.98 (0.48-8.13)	1.72 (0.25-11.87)	1.97 (0.61-6.18)	1.88 (0.60-5.88)
Previous abortion	1.11 (0.27-4.57)	0.75 (0.08-7.07)	1.14 (0.34-3.76)	0.98 (0.30-3.24)
Parity (number of children)	1.02 (0.25-4.20)	0.99 (0.14-6.85)	1.10 (0.35-3.50)	1.01 (0.32-3.16)
Age of mother at birth of first child (years)	1.73 (0.23-13.28)	0.57 (0.06-5.26)	0.98 (0.22-4.15)	1.13 (0.26-4.88)
Gestational age (weeks)	2.39 (0.60-9.58)	1.76 (0.19-16.2)	2.56 (0.80-8.48)	2.18 (0.67-7.06)

* Gestational weight gain classified according to the Institute of Medicine (IOM, 1990).
† Reference categories: sex (female), mother's age (< 20 years), educational level (< 8 years), total family income (< 500 reais), previous caesarian delivery (no), previous abortion (no), parity (one child), age of mother at birth of first child (< 17years), gestational age (< 41 weeks).
‡ There were no cases of macrossomia in this sample.

Table 5 - Final logistic regression model for macrossomia (Rio de Janeiro, 1999-2001)

Variable	OR	95%CI	p
Excessive gestational weight gain *			
No	1.00		
Yes	5.83	1.51-22.48	0.0104
Mother's age (years)			
< 20	1.00		
≥ 20	4.38	0.76-25.28	0.0982

* Gestational weight gain classified according to the Institute of Medicine (IOM, 1990).

does not invalidate the conclusions of the study since the results that involve this variable are highly consistent, in other words, the OR value is high (5.83) in addition to being backed up by a high level of statistical significance (p value = 0.0104). Another justification is based on the fact that previous analyses[20] revealed significant differences between the different gestational weight gain categories for the maternal obesity outcome. Furthermore, values that are available for 3082 expectant mothers resident in six Brazilian state capitals, between 1991 and 1995, reveal a mean gestational weight gain of 12.7 kg,[14] which value is very close to the figure observed in the present study (12.9 kg), which points in the opposite direction to the presence of a bias. The low number of macrossomia cases (n = 11) does not go as far as being a limitation, despite potentially configuring a sample problem. Nevertheless, even with this reduced number of cases, it was possible to demonstrate an effect from excessive gestational weight gain as a factor potentially associated with macrossomia.

With the objective of increasing the consistency and relevance of the results presented here, similar analyses were performed taking extended length at birth as the dependent variable. This was defined as a length for age index as above 2 z-scores. It is interesting to note that, in contrast with what was observed for birth weight, no statistically significant results were observed for extended length at birth, for which reason these results are not presented here.

In synthesis, based on the results of the present investigation, it was observed that excessive gestational weight gain, according to the Institute of Medicine recommendations, is a factor that is potentially associated with macrossomia. While the figures for macrossomia incidence were low, it is fundamental that the magnitude, determinants and historical tendencies of this condition be monitored in a systematic manner, bearing in mind that macrossomia is already a significant public health problem in countries that are at more advanced stages of nutritional transition.

References

1. McCormick MC. The contribution of low birth weight to infant mortality and childhood morbidity. N Engl J Med. 1985;312:82-90.
2. Kramer MS. Determinants of low birth weight: methodological assessment and meta-analysis. Bull World Health Organ. 1987;65:663-737.

3. Horta BL, Barros FC, Halpern R, Victora CG. Baixo peso ao nascer em duas coortes de base populacional no Sul do Brasil. Cad Saúde Pública. 1996;12 (Supl 1):27-31.
4. Monteiro CA, Benício MH, Ortiz LP. Tendência secular do peso ao nascer na cidade de São Paulo (1976-1998). Rev Saúde Pública. 2000;34 (Supl 6):26-40.
5. Gama SG, Szwarcwald CL, Leal MD, Theme Filha MM. The pregnancy during adolescence as a risk factor for low birth weight, Brazil. Rev Saúde Pública. 2001;35:74-80.
6. Ramakrishnan U. Nutrition and low birth weight: from research to practice. Am J Clin Nutr. 2004;79:17-21.
7. Institute of Medicine (IOM). Nutrition during pregnancy, weight gain and nutrient supplements. Report of the Subcommittee on Nutritional Status and Weight Gain during Pregnancy. Washington, DC: National Academy Press; 1990.
8. Abrams B, Selvin S, Gunderson EP. Pregnancy weight gain: still controversial. Am J Clin Nutr. 2000;71(Suppl):S1233-41.
9. Galtier-Dereure F, Boegner C, Bringer J. Obesity and pregnancy: complications and cost. Am J Clin Nutr. 2000;71(Suppl 5):S1242-8.
10. Butte NF, Ellis KJ, Wong WW, Hopkinson JM, Smith EO. Composition of gestational weight gain impacts maternal fat retention and infant birth weight. Am J Obstet Gynecol. 2003;189:1423-32.
11. Rodrigues S, Robinson EJ, Kramer MS, Gray-Donald K. High rates of infant macrosomia: a comparison of a Canadian native and a non-native population. J Nutr. 2000;130:806-12.
12. Jolly MC, Sebire NJ, Harris JP, Regan L, Robinson S. Risk factors for macrosomia and its clinical consequences: a study of 350,311 pregnancies. Eur J Obstet Gynecol Reprod Biol. 2003;111:9-14.
13. Lizo CL, Azevedo-Lizo Z, Aronson E, Segre EA. Relação entre ganho de peso materno e peso do récem nascido. J Pediatr (Rio J). 1998;74:114-8.
14. Nucci LB, Duncan BB, Mengue SS, Branchtein L, Schmidt MI, Fleck ET. Assessment of weight gain during pregnancy in general prenatal care services in Brazil. Cad Saúde Pública. 2001a;17:1367-74.
15. Berard J, Dufour P, Vinatier D, Subtil D, Vanderstichele S, Monnier JC, et al. Macrosomia: risk factors and outcome. A study of the outcome concerning 100 cases > 4500 g. Eur J Obstet Gynecol Reprod Biol. 1998;77:51-9.
16. ACOG. Technical Bulletin number 159. Fetal macrosomia. Int J Gynecol Obstet. 1992;39:341-5.
17. Kac G. Fatores determinantes da retenção de peso pós-parto em uma coorte de mulheres com nove meses de seguimento [tese]. São Paulo: Faculdade de Saúde Pública, USP; 2002.
18. Kac G, Benício MH, Valente JG, Velasquez-Melendez G. Postpartum weight retention among women in Rio de Janeiro: a follow-up study. Cad Saúde Pública. 2003;19(Supl 1):S149-61.
19. Kac G, Benício MH, Velásquez-Meléndez G, Valente JG, Struchiner CJ. Breastfeeding and postpartum weight retention in a cohort of Brazilian women. Am J Clin Nutr. 2004;79:487-93.
20. Kac G, Benício MH, Velásquez-Meléndez G, Valente JG, Struchiner CJ. Gestational weight gain and prepregnancy weight influence postpartum weight retention in a cohort of Brazilian women. J Nutr. 2004;134:661-6.
21. Kac G, Benício MH, Velásquez-Meléndez G, Valente JG. Nine months postpartum weight retention predictors for Brazilian women. Public Health Nutr. 2004;7:621-8.
22. Ministério da Saúde (MS). Assistência Pré-natal. Manual Técnico. Brasília: Ministério da Saúde, 2000.
23. Lohman TG, Roche AF, Martorell R. Anthropometric Standardization Reference Manual. Illinois: Human Kinetics Books; 1988.
24. Conselho Nacional de Saúde (CSN). Resolução nº 196/96 sobre pesquisa envolvendo serem humanos. Bioética. 1996;4:415-25.
25. Armstrong IE, Robinson EJ, Gray-Donald K. Prevalence of low and high birthweight among the James Bay Cree of northern Quebec. Can J Public Health. 1998;89:419-20.
26. Caulfield LE, Harris SB, Whalen EA, Stugamori ME. Maternal nutritional status, diabetes and risk of macrosomia among native Canadian women. Early Human Dev. 1998;50:293-303.
27. Pettit DJ, Bennet PH, William C, Kwnoler H, Baird R, Aleck KA. Gestational diabetes mellitus and impaired glucose tolerance during pregnancy. Long-term effect on obesity and glucose tolerance in the offspring. Diabetes. 1985;34:119-22.
28. Boyd ME, Usher RH, McLean FH. Fetal macrosomia. Prediction, risks, proposed management. Obstet Gynecol. 1983;61:715-22.
29. Bergman RL, Richter R, Bergman KE, Plagemann A, Brauer M, Dudenhausen JW. Secular trends in neonatal macrosomia in Berlin. Influences of potential determinants. Paediatr Perinat Epidemiol. 2003;17:244-9.
30. Orskou J, Kesmodel U, Heriksen TB, Secher NJ. An increasing proportion of infants weigh more than 4000 grams at birth. Acta Obstet Gynecol Scand. 2001;809:931-6.
31. Nucci LB, Schmidt MI, Duncan BB, Fuchs SC, Fleck ET, Santos Britto MM. Nutritional status of pregnant women: prevalence and associated pregnancy outcomes. Rev Saúde Pública. 2001;35:502-7.

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