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Breast-feeding duration for the prevention of excess body weight of mother–child pairs concurrently: a 2-year cohort study

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Abstract

Objective: To examine the association between breast-feeding duration and the risk of excess body weight (children >85th percentile, mothers BMI ≥ 25·0 kg/m^2) concurrently in mother–child pairs two years after delivery.

Design: Prospective cohort study in Joinville, Brazil. Multivariable logistic regression was used to examine the independent relationship between breast-feeding duration and risk of excess body weight.

Setting: Brazilian public maternity hospital.

Subjects: Three hundred and five mother–child pairs.

Results: At 2-year follow-up, 23·6 % of mother–child pairs had excess body weight. Children breast-fed for <2 months were more likely to have excess body weight than children breast-fed for ≥6 months (OR = 2·4; 95 % CI 1·1, 5·1). Breast-feeding for <2 months was also associated with a greater likelihood of maternal excess body weight compared with those who breast-fed for ≥6 months (OR = 2·9; 95 % CI 1·1, 8·1). There was a progressive increase in the likelihood of mother–child pairs having excess body weight as breast-feeding duration decreased. In addition to breast-feeding duration, other independent determinants of excess body weight were pre-pregnancy weight, gestational weight gain and number of pregnancies in mothers, and birth weight in children.

Conclusions: Breast-feeding for a longer duration has a parallel protective effect on the risk of excess body weight in mother–child pairs two years after birth. Since members of the same family could be influenced by the same risk factors, continued promotion and support of breast-feeding may help to attenuate the rising prevalence of overweight in mother–child pairs.

Keywords
Breast-feeding
Overweight
Childhood obesity
Birth cohort
Postpartum weight
Maternal obesity

The worldwide prevalence of overweight and obesity in adults and children has increased substantially in the last 30 years and, as such, has become a major global health challenge[1]. In Brazil from 1975 and 2009, the prevalence of overweight and obesity in adult women increased from 28·7 to 48·0 % and from 8·0 to 16·9 %, respectively[2]. Over the same time period, the prevalence of obesity in Brazilian children aged 5–9 years increased from 2·4 to 14·2 %[2].

The postpartum period has been identified as a time of increased vulnerability for maternal weight gain[3]. Failure to lose weight after pregnancy is an important predictor of long-term obesity, increasing a mother's risk for CVD, hypertension, diabetes and degenerative joint disease[4,5]. This time period may also be crucial for the long-term weight status of the child, as increasing evidence has emerged showing that both excessive weight gain and fast weight gain in early childhood are associated with excess body weight later in life[6–8]. Thus, the postpartum period and early infancy provide an important public health opportunity for the primary prevention of obesity for both mother and child[9].

It has been proposed that maternal lactation and early feeding practices decrease both maternal postpartum weight retention and the development of obesity in childhood. However, evidence that breast-feeding duration has a protective effect for either mother or child has been equivocal. Several longitudinal studies have shown that children who were breast-fed for a shorter duration during infancy were less satiety responsive[10], had more

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unhealthy snacking behaviours[11] and were at higher risk of being overweight/obese[11–24]. Additionally, longitudinal studies conducted in Sweden, Germany, Australia, the USA, Denmark and Brazil have reported that breast-feeding for a longer duration was associated with a decreased risk of maternal postpartum excess body weight[1,18,22,25–28]. Other studies, however, have reported small or no protective effects of breast-feeding duration on obesity in children[10,29–38] or in women after delivery[37].

A causal link between breast-feeding duration and childhood obesity has been difficult to establish[39] mainly because of confounding maternal, child, cultural, genetic and environmental variables[40]. In addition, most studies performed to date have been cross-sectional. Only three prospective cohort studies have evaluated the association between breast-feeding duration and excess body weight individually in mothers and their children[18,22,41], and no cohort study, to our knowledge, has performed such analysis concurrently in mother–child pairs for two years. This is important from a public health perspective since members of the same family are influenced by several of the same risk factors, some of which may be modified with pre- and postnatal care. Therefore, in the present study, we investigated the relationship between breast-feeding duration and risk of excess body weight in Brazilian women in concert with their children two years after delivery.

Methods

Study design and population

Data came from the Predictors of Maternal and Infant Excess Body Weight (PREDI) Study. Recruitment for this prospective cohort study took place between 14 January and 16 February 2012 at the public maternity hospital in Joinville, a city of about 500 000 inhabitants in Santa Catarina, Brazil. Details of the recruitment process have been previously described[42,43]. Briefly, all women over the age of 18 years, who gave birth to a full-term singleton (between 37 and 42 weeks of gestation), were invited to participate with their newborn infants in the first stage of the study (first investigation). Exclusion criteria included pre-eclampsia, the presence of an infectious contagious disease (AIDS, hepatitis, syphilis and toxoplasmosis), birth defects and plans for adoption immediately after delivery. Of the 529 eligible pairs (mothers and infants), fifty-eight did not meet the study criteria and thirty-six were not considered for other reasons, resulting in a total of 435 mother–infant pairs who participated in the first investigation (Fig. 1).

The second stage of the study (second investigation) was carried out in the homes of the participants between March 2013 and March 2014. All mothers and children who participated in the first stage of the study were invited to participate in the study's second stage. Children with an

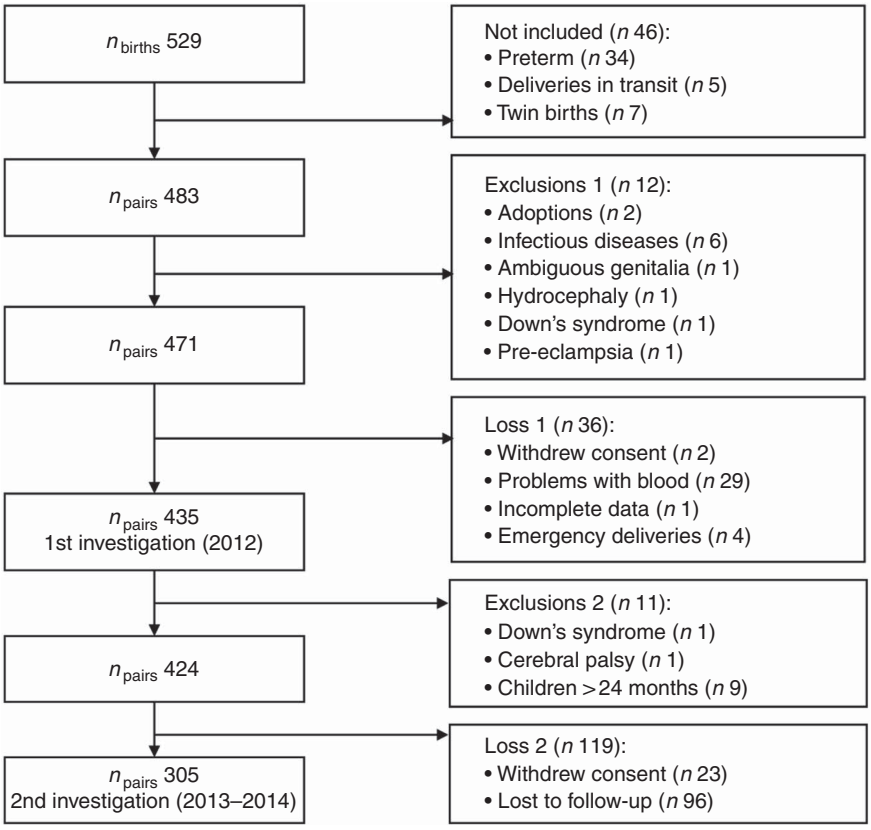

Fig. 1 Flow chart of participants through the recruitment process, Joinville, Brazil

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anomaly that interfered with anthropometric measurements were excluded from the second investigation. Of the 435 pairs who participated in the first investigation, eleven did not meet the inclusion criteria for the second investigation and 119 were considered lost to follow-up, resulting in 305 (70·1 %) mother–child pairs (Fig. 1).

Data collection

First investigation

Within 48 h after the birth of their infant, mothers received information about the study. If both mother and infant met the study's inclusion criteria, they were invited to participate by providing informed consent.

Once enrolled in the study, mothers completed a previously tested structured questionnaire to collect demographic, socio-economic, anthropometric, obstetric and reproductive information on themselves and their newborns. Details of the data collection tools have been previously described[42,43]. The questionnaire was administered by trained health professionals in a private maternity hospital room within 48 h after delivery, at the time we assessed their postpartum height. Postpartum height was measured to the nearest 0·1 cm using a portable stadiometer (WCS®, Compact model) on a wall without skirting. The mothers stood in an orthostatic position, wearing light clothing with no shoes and having their weight evenly distributed. Pre-pregnancy BMI ([weight (kg)]/[height (m)]^2) was calculated based on the mothers' self-reported pre-pregnancy weight and postpartum measured height. Pre-pregnancy weight was classified according to the WHO BMI cut-offs[44], which classify individuals with a BMI < 18·5 kg/m^2 as being underweight, BMI between 18·5 and 24·9 kg/m^2 as being normal weight, BMI between 25·0 and 29·9 kg/m^2 as being overweight, and BMI ≥ 30·0 kg/m^2 as being obese. We combined underweight (*n* 19) and normal weight (*n* 251) mothers into one category (pre-pregnancy BMI < 25·0 kg/m^2).

Gestational weight gain (GWG) was obtained by subtracting the pre-pregnancy weight from the weight at delivery (measured on the day of delivery). The adequacy of GWG was assessed according to the 2009 Institute of Medicine guidelines, which state that underweight women should gain between 12·5 and 18·0 kg, women with adequate BMI between 11·5 and 16·0 kg, overweight women between 7·0 and 11·5 kg, and obese women between 5·0 and 9·0 kg[45].

Birth weight and length of the infants were collected from hospital records. Birth weight was classified into three categories according to gestational age and sex: small for gestational age (SGA; <10th percentile), adequate for gestational age (AGA; 10–90th percentile) and large for gestational age (LGA; >90th percentile)[46].

Second investigation

Trained personnel completed the second investigation data collection at the homes of the study participants. Anthropometric measurements were performed on both mother and child and demographic and socio-economic information was collected individually using a previously tested structured questionnaire in a private room of the family's home. Children's weight was measured to the nearest 10 g using a paediatric digital portable scale (Beurer®, BY20 model) and length was measured to the nearest 0·1 cm using a paediatric anthropometric ruler (WCS®, Wood model).

The children's weight status was divided into two categories based on the 2006 WHO growth standards for weight-for-age: >85th percentile and ≤85th percentile[47]. The mothers' height was measured using the same equipment and procedures as employed in the first investigation. Their weight was measured on a digital scale (Plenna®, Acqua model) with a capacity of 180 kg to the nearest 0·1 kg while wearing light clothes without shoes and accessories (jewellery, watches, coats). All anthropometric measures were performed in duplicate in both the first and second investigations. The mean of the two measurements was used for analysis. Maternal weight status was classified using the same WHO BMI cut-offs[44] as employed in the first investigation for pre-pregnancy weight.

Breast-feeding duration (in months) was self-reported by the mothers. Breast-feeding was classified according to the WHO indicators for assessing infant and young child feeding practices, which define 'exclusive breast-feeding' when the infant receives only breast milk or expressed milk and no other liquid or solid (except for drops or syrups of vitamins, minerals and/or medications) for a period of 6 months or more; 'predominant breast-feeding' when the infant receives breast milk or expressed milk, as well as water and water-based drinks such as fruit juice and tea; 'complementary feeding' when the infant receives breast milk or expressed milk, as well as solid or semi-solid foods, non-human milk and special formula; 'breast-feeding' when the infant receives breast milk or expressed milk, as well as non-human milk and special formula; and 'artificial feeding' when the infant receives any type of liquid or semi-solid food in a bottle, including breast milk, non-human milk and special formula[48]. For the current study, all non-exclusive breast-feeding categories were grouped into a single non-exclusive breast-feeding category[48].

Statistical analyses

Data were analysed using the statistical software package IBM SPSS Statistics version 22.0. To examine the differences between the mother–child pairs who participated in the second investigation (*n* 305) and those who did not participate (*n* 130 from the first investigation), we used the χ^2 test to compare the variables age, education, birth weight and sex. The χ^2 test was also used to compare the prevalence of categorical variables according to weight status of the children (>85th percentile and ≤85th

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percentile) and the mothers (underweight/normal weight, overweight and obese). Mother's age (<20, 20–30 and ≥30 years old) and monthly household income (<3, 3–5 and ≥5 minimum salaries) were classified according to the Brazilian Institute of Geography and Statistics' criteria[49]. For mother's age we grouped the categories of 20–24 years and 25–29 years into a single category (20–30 years). Mother's education (<9 years for the mothers who completed primary school; 9–12 years for those who completed high school; ≥12 years for those who started/finished undergraduate courses) was classified according to the 1996 Education Law (Lei das Diretrizes e Bases da Educação Nacional)[50].

To investigate the association of children with a weight status >85th percentile and mothers with a BMI ≥ 25·0 kg/m^2 with breast-feeding duration and other risk factors, the OR and 95 % CI were calculated using logistic regression. Unadjusted analyses (Models 1, 3 and 5) were used to estimate the crude association of each exposure with the outcome for children with a weight status >85th percentile, mothers with a BMI ≥ 25·0 kg/m^2 and mother–child pairs concurrently with excess body weight (children with a weight status >85th percentile and mothers with a BMI ≥ 25·0 kg/m^2), relative to children with a weight status ≤85th percentile, mothers with a BMI < 25·0 kg/m^2 and mother–child pairs without excess body weight, respectively. The covariates breast-feeding duration, months since delivery, sex, birth weight, type of delivery, mother's age, mother's education, marital status, monthly household income, smoking after pregnancy, pre-pregnancy BMI, GWG and number of pregnancies were simultaneously considered in multivariable logistic regression models (Models 2, 4 and 6) to reveal the independent importance of breast-feeding duration on excess body weight. These variables have been shown in the literature to be related with both breast-feeding duration and the outcome of interest. We performed the variance inflator factor test with commonly applied cut-off values to reveal little collinearity among the independent variables[51]. All analyses were considered statistically significant when $P < 0·05$.

Results

The χ^2 tests for proportionality showed no significant difference in age, education, birth weight and sex between the mother–child pairs enrolled in the second investigation (*n* 305) and those enrolled in the first investigation only (*n* 435). The characteristics of the mothers and children grouped by weight status are presented in Table 1. Of the 305 mothers and children included in the study, 126 (41·6 %) children had a body weight >85th percentile. A larger proportion of children who were breast-fed for <2 months (56·9 %) or who were LGA at birth (56·8 %) had a body weight >85th percentile at 2 years of age compared with children who were breast-fed for longer or who were SGA or AGA at birth. At 2-year follow-up, 146 (48·8 %) mothers were either overweight or obese (BMI ≥ 25·0 kg/m^2). Compared with those who were underweight/normal weight, a greater proportion of overweight and obese mothers had caesarean sections (53·6 %), were overweight/obese prior to pregnancy (90·4 %), had excessive GWG (68·1 %) and a greater number of pregnancies (59·6 %; Table 1).

Table 2 presents the characteristics of mother–child pairs by weight status two years after delivery. Regarding mother–child pairs, 71 (23·6 %) were found to have excess body weight in both mother and child (children >85th percentile and mothers BMI ≥ 25·0 kg/m^2) at 2-year follow-up. There was a significant increase in the proportion of mother–child pairs with excess body weight in the mothers who had excessive GWG (13·5 to 35·5 %, $P < 0·01$) and had breast-fed for less time (18·0 to 36·0 %, $P = 0·02$).

Table 3 presents the determinants of excess body weight in children, mothers and mother–child pairs at 2-year follow-up. Unadjusted analyses (Model 1) showed that as breast-feeding duration decreased the likelihood of children having excess body weight progressively increased (OR = 1·3; 95 % CI 0·7, 2·3; $P = 0·40$, OR = 2·0; 95 % CI 1·0, 4·1; $P = 0·04$ and OR = 2·7; 95 % CI 1·5, 7·0; $P < 0·01$, for 4– < 6, 2– < 4 and <2 months, respectively). Children who were LGA at birth or who had mothers who gained excessive weight during pregnancy also had a significantly greater likelihood of having excess body weight at follow-up (OR = 2·4; 95 % CI 1·4, 4·0; $P < 0·01$ and OR = 1·6; 95 % CI 1·0, 2·5; $P < 0·04$, respectively). These results did not change substantially after adjusting for important potential confounding variables (Model 2). Children who were breast-fed for <2 months were 2·4 (95 % CI 1·1, 5·1; $P = 0·02$) times as likely to have excess body weight compared with children who were breast-fed for ≥6 months (Model 2). Children who were LGA at birth and those whose monthly household income was <3 minimum salaries also had a significantly greater likelihood of having excess body weight compared with SGA/AGA children and those with a monthly household income ≥3 minimum salaries (OR = 2·7; 95 % CI 1·5, 4·9; $P < 0·01$ and OR = 1·8; 95 % CI 1·0, 3·1; $P = 0·03$, respectively).

Regarding the mothers, unadjusted analyses in Table 3 revealed that breast-feeding duration, time since delivery, pre-pregnancy BMI, excessive GWG and number of pregnancies were significantly associated with an increased risk of being overweight/obese at follow-up (Model 3). After adjusting for potential confounders, breast-feeding duration, pre-pregnancy BMI, GWG and number of pregnancies showed independent effects on excess body weight (Model 4). Mothers who breast-fed for <2 months were 2·9 (95 % CI 1·1, 8·1; $P = 0·04$) times as likely to be overweight/obese when compared with those who breast-fed for ≥6 months (Model 4).

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Table 1 Characteristics of mothers and their children by weight status two years after delivery (*n* 301)*, Joinville, Brazil 2013–2014

	Children's weight status							Mother's weight status								
	≤85th percentile (58·7 %)		>85th percentile (41·3 %)		Total (100·0 %)			Underweight/normal weight (51·2 %)		Overweight (28·6 %)		Obese (20·2 %)		Total (100·0 %)		
Characteristic	*n*	%	*n*	%	*n*	%	*P* value	*n*	%	*n*	%	*n*	%	*n*	%	*P* value
Children																
Breast-feeding duration (months)†							0·02									0·18
≥6	69	67·0	34	33·0	103	34·0		60	60·0	20	20·0	20	20·0	100	33·4	
4–<6	62	61·4	39	38·6	101	33·3		48	47·5	32	31·7	21	20·8	101	33·8	
2–<4	24	50·0	24	50·0	48	15·8		20	41·7	15	31·2	13	27·1	48	16·1	
<2	22	43·1	29	56·9	51	16·9		25	50·0	18	36·0	7	14·0	50	16·7	
Type of breast-feeding†							0·04									0·12
Exclusive	70	66·0	36	34·0	106	35·0		61	59·2	21	20·8	21	20·4	103	34·4	
Non exclusive	107	54·3	90	45·7	197	65·0		92	47·0	64	32·6	40	20·4	196	65·6	
Time since delivery (months)							0·07									0·13
<18	123	62·4	74	37·6	197	65·5		107	55·4	51	26·5	35	18·1	193	64·1	
≥18	56	51·8	52	48·1	108	34·5		47	43·5	35	32·4	26	24·1	108	35·9	
Sex							0·82									0·48
Male	90	58·0	65	42·0	155	50·8		77	50·3	41	26·8	35	22·9	153	50·8	
Female	89	59·3	61	40·7	150	49·2		77	52·0	45	30·4	26	17·6	148	49·2	
Birth weight							<0·01									0·15
SGA/AGA	144	64·2	80	35·8	224	73·4		120	54·3	61	27·6	40	18·1	221	73·4	
LGA	35	43·2	46	56·8	81	26·6		34	42·5	25	31·3	21	26·2	80	26·6	
Type of delivery							0·53									0·03
Normal	124	60·0	83	40·0	207	67·8		109	53·4	62	30·4	33	16·2	204	67·8	
Caesarean section	55	56·1	43	43·9	98	32·2		45	46·4	24	24·7	28	28·9	97	32·2	
Mothers																
Age (years)							0·37									0·14
20–30	109	57·7	80	42·3	189	62·0		5	55·6	1	11·1	3	33·3	9	3·0	
<20	8	80·0	2	20·0	10	3·3		102	54·8	54	29·0	30	16·1	186	61·8	
≥30	62	58·5	44	41·5	106	34·7		47	44·3	31	29·4	28	26·4	106	35·2	
Education (years)							0·58									0·16
≥12	42	63·3	24	36·7	66	21·6		34	52·3	20	30·7	11	16·9	65	21·6	
9–12	82	56·1	64	43·9	146	47·9		81	56·2	39	27·1	24	16·7	144	47·8	
<9	55	59·1	38	40·8	93	30·5		39	42·4	27	29·3	26	28·3	92	30·6	
Marital status							0·89									0·34
Marriage/consensual union	160	58·8	112	41·2	272	89·2		134	49·8	80	29·7	55	20·0	269	89·4	
Others	19	57·6	14	42·4	33	10·8		20	62·6	6	18·7	6	18·7	32	10·6	
Monthly household income (MS)‡							0·26									0·05
≥5	36	65·4	19	34·5	55	18·2		87	50·0	43	24·7	44	25·3	174	58·4	
3–5	44	62·8	26	37·2	70	23·2		41	58·6	20	28·6	9	12·8	70	23·5	
<3	97	54·8	80	45·2	177	58·6		26	48·1	21	38·9	7	12·9	54	18·1	
Working/studying after delivery†							0·07									0·16
No	78	65·0	42	35·0	120	39·6		55	46·6	33	28·0	30	25·4	118	39·5	
Yes	100	54·6	83	45·4	183	60·4		98	54·1	53	29·3	30	16·6	181	60·5	
Smoking after pregnancy							0·46									0·27
No	154	57·9	112	42·1	266	87·2		137	52·1	71	27·0	55	20·9	263	87·4	
Yes	25	64·1	14	35·9	39	12·8		17	44·7	15	39·5	6	15·8	38	12·6	

Table 1 *Continued*

	Children's weight status							Mother's weight status								
	≤85th percentile (58·7 %)		>85th percentile (41·3 %)		Total (100·0 %)			Underweight/normal weight (51·2 %)		Overweight (28·6 %)		Obese (20·2 %)		Total (100·0 %)		
Characteristic	*n*	%	*n*	%	*n*	%	*P* value	*n*	%	*n*	%	*n*	%	*n*	%	*P* value
Pre-pregnancy BMI (kg/m^2)							0·70									<0·01
<25	114	60·0	76	40·0	190	62·3		143	76·5	41	21·9	3	1·6	187	62·1	
25–30	45	58·4	32	41·6	77	25·2		10	13·2	38	50·0	28	36·8	76	25·3	
≥30	20	52·6	18	47·3	38	12·5		1	2·6	7	18·4	30	79·0	38	12·6	
Gestational weight gain							0·04									<0·01
Adequate	106	63·8	60	36·2	166	54·4		110	67·5	31	19·0	22	13·5	163	54·2	
Excessive	73	52·5	66	47·5	139	45·6		44	31·9	55	39·8	39	28·3	138	48·8	
Pregnancies (*n*)							0·94									<0·01
2	63	59·4	43	40·6	106	34·7		70	67·9	25	24·3	8	7·8	103	34·2	
3	48	57·1	36	42·9	84	27·5		38	45·2	26	30·9	20	23·8	84	27·9	
≥4	68	59·1	47	40·9	115	37·8		46	40·4	35	30·7	33	28·9	114	37·9	

SGA, small for gestational age; AGA, adequate for gestational age; LGA, large for gestational age; MS, minimum salary ($US 306·00).
**n* 301, four mothers refused to have their anthropometric measurements assessed.
†Two participants did not know the breast-feeding duration, two participants did not know the type of breast-feeding and two participants did not know when they started working/studying after delivery.
‡Three participants did not know the monthly household income.

Models 5 and 6 in Table 3 present data from the analyses of mother–child pairs who were both categorized as having excess body weight. Breast-feeding duration, time since delivery, child's birth weight, maternal pre-pregnancy BMI and GWG were significantly associated with an increased risk of excess body weight concurrently on mother–child pairs (Model 5). Except for time since delivery, these associations continued to be significant after adjusting for confounders (Model 6). Furthermore, there was a progressive increase in the likelihood of concurrent excess body weight in mother–child pairs as breast-feeding duration decreased (Model 6: OR = 0·9; 95 % CI 0·4, 2·0; $P = 0·71$, OR = 1·7; 95 % CI 0·6, 4·3; $P = 0·30$ and OR = 3·2; 95 % CI 1·3, 8·2; $P = 0·01$ for 4–<6, 2–<4 and <2 months, respectively).

The risk of excess body weight in mothers and their children according to breast-feeding duration is depicted in Fig. 2. Estimates were adjusted for time since delivery, sex, birth weight, type of delivery, mother's age, mother's education, marital status, household income, smoking after pregnancy, pre-pregnancy BMI, GWG and number of pregnancies. The reference group was considered those who breast-fed for ≥6 months. Mothers and children who partook in breast-feeding for <2 months had the greatest risk of excess body weight at follow-up, with mothers having a greater risk than children. The greatest risk was observed when analysis was performed concurrently on mother–child pairs.

Discussion

In the current investigation, we found that the risk of a mother and her child having excess body weight progressively increases as breast-feeding duration decreases. Furthermore, our findings indicated that longer breast-feeding duration is an independent contributor to reducing the risk of excess body weight in children and mothers individually, as well as concurrently in both the mother and her child, even when other possible confounding factors such as birth weight, pre-pregnancy BMI and GWG are considered.

Although this protective effect has been reported in several other studies[1,11–28], many longitudinal studies have produced conflicting results regarding the benefits of breast-feeding duration on the prevention of excess body weight in mothers and children. The majority of these longitudinal prospective studies, however, did not investigate both mothers and children concurrently, but rather either only the mothers or only the children[11–17,19–21,23,28,37,52]. The current study design in which analyses of mother–child pairs was concurrently performed is important from a public health perspective since members of the same family could be influenced by several of the same risk factors, some of which may be modified with pre- and postnatal care. Increasing our understanding on how breast-feeding duration may impact

Table 2 Characteristics of mother–child pairs by weight status two years after delivery (*n* 301), Joinville, Brazil, 2013–2014

	Weight status (BMI)						
	Children ≤85th percentile, mothers BMI < 25 kg/m^2 (76·4 %)		Children >85th percentile, mothers BMI ≥ 25 kg/m^2 (23·6 %)		Total (100·0 %)		
Characteristic	*n*	%	*n*	%	*n*	%	*P* value
Children							
Breast-feeding duration (months)*							0·02
≥6	82	82·0	18	18·0	100	33·5	
4– <6	82	81·2	19	18·8	101	33·8	
2– <4	32	66·7	16	33·3	48	16·0	
<2	32	64·0	18	36·0	50	16·7	
Type of breast-feeding*							0·11
Exclusive	84	81·6	19	18·4	103	34·4	
Non exclusive	144	73·5	52	26·5	196	65·6	
Time since delivery (months)							0·03
<18	155	80·3	38	19·7	193	64·1	
≥18	75	69·4	33	30·6	108	35·9	
Sex							0·98
Male	117	76·5	36	23·5	153	50·8	
Female	113	76·4	35	23·6	148	49·2	
Birth weight							<0·01
SGA/AGA	181	81·9	40	18·1	221	73·4	
LGA	49	61·2	31	38·8	80	26·6	
Type of delivery							0·23
Normal	160	78·4	44	21·6	204	67·8	
Caesarean section	70	72·2	27	27·8	97	33·2	
Mothers							
Age (years)							0·96
20–30	143	76·9	43	23·1	186	61·8	
<20	7	77·8	2	22·2	9	3·0	
≥30	80	75·5	26	24·5	106	35·2	
Education (years)							0·84
≥12	51	78·5	14	21·5	65	21·6	
9–12	108	75·0	36	25·0	144	47·8	
<9	71	77·2	21	22·8	92	30·6	
Marital status							0·84
Marriage/consensual union	206	76·6	63	23·4	269	89·4	
Others	24	75·0	8	25·0	32	10·6	
Monthly household income (MS)†							0·53
≥5	41	75·9	13	24·1	54	18·1	
3–5	57	81·4	13	18·6	70	23·5	
<3	130	74·7	44	25·3	174	58·4	
Working/studying after delivery*							0·78
No	89	75·4	29	24·6	118	39·5	
Yes	139	76·8	42	23·2	181	60·5	
Smoking after pregnancy							0·67
No	202	76·8	61	23·2	263	87·4	
Yes	28	73·7	10	26·3	38	12·6	
Pre-pregnancy BMI (kg/m^2)							<0·01
<25·0	164	87·7	23	12·3	187	62·2	
25·0–30·0	46	60·5	30	39·5	76	25·2	
≥30·0	20	52·6	18	47·4	38	12·6	
Gestational weight gain							<0·01
Adequate	141	86·5	22	13·5	163	54·2	
Excessive	89	64·5	49	35·5	138	45·8	
Pregnancies (*n*)							0·25
2	84	81·6	19	18·4	103	34·2	
3	60	71·4	24	28·6	84	27·9	
≥4	86	75·4	28	24·6	114	37·9	

SGA, small for gestational age; AGA, adequate for gestational age; LGA, large for gestational age; MS, minimum salary ($US 306·00).
**n* 299, two mothers did not know the breast-feeding duration, two mothers did not know the type of breast-feeding and two mothers did not know when they started working/studying after delivery.
†*n* 298, three mothers did not know the monthly household income.

the future body weight of both mother and child will inform health professionals who have contact with women during their pregnancies and in the postpartum period about the importance of encouraging mothers to continue to breast-feed for at least the first 6 months of their child's life.

According to Gillman *et al.*[14], there are at least two mechanisms that may explain how longer breast-feeding duration protects infants against being overweight later in life. The first is behavioural and is related to children's own natural control of energy intake[14].

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Table 3 Determinants of excess body weight at two years postpartum among Brazilian mothers (*n* 301) and their children (*n* 305), Joinville, Brazil, 2013–2014

	Children (*n* 305)						Mothers (*n* 301)						Mother–child pairs (*n* 71)					
	Model 1*			Model 2†			Model 3*			Model 4†			Model 5*			Model 6†		
Characteristic	OR	95 % CI	*P* value	OR	95 % CI	*P* value	OR	95 % CI	*P* value	OR	95 % CI	*P* value	OR	95 % CI	*P* value	OR	95 % CI	*P* value
Breast-feeding duration (months)																		
≥6	Reference			Reference			Reference			Reference			Reference			Reference		
4– <6	1·3	0·7, 2·3	0·40	1·4	0·7, 2·6	0·33	1·7	0·9, 2·9	0·07	2·1	0·9, 5·1	0·08	1·1	0·5, 2·2	0·88	0·9	0·4, 2·0	0·71
2– <4	2·0	1·0, 4·1	0·04	1·8	0·8, 3·7	0·15	2·1	1·0, 4·2	0·03	2·5	0·9, 7·2	0·08	2·3	1·0, 5·0	0·04	1·7	0·6, 4·3	0·30
<2	2·7	1·5, 7·0	<0·01	2·4	1·1, 5·1	0·02	1·5	0·8, 2·9	0·24	2·9	1·1, 8·1	0·04	2·6	1·2, 5·5	0·01	3·2	1·3, 8·2	0·01
Months since delivery																		
<18	Reference			Reference			Reference			Reference			Reference			Reference		
≥18	1·5	0·9, 2·5	0·07	1·7	1·0, 2·9	0·05	1·6	1·0, 2·6	0·04	1·8	0·9, 3·8	0·11	1·8	1·0, 3·0	0·03	1·8	0·9, 3·5	0·09
Sex																		
Male	Reference			Reference			Reference			Reference			Reference			Reference		
Female	0·9	0·6, 1·5	0·82	0·9	0·6, 1·5	0·79	0·9	0·6, 1·5	0·76	1·0	0·5, 1·9	0·88	1·0	0·6, 1·7	0·98	1·0	0·5, 1·8	0·88
Birth weight																		
SGA/AGA	Reference			Reference			Reference			Reference			Reference			Reference		
LGA	2·4	1·4, 4·0	<0·01	2·7	1·5, 4·9	<0·01	1·6	1·0, 2·7	0·07	1·5	0·7, 3·3	0·33	2·9	1·6, 5·0	<0·01	3·3	1·6, 6·6	<0·01
Type of delivery																		
Normal	Reference			Reference			Reference			Reference			Reference			Reference		
Caesarean section	1·2	0·7, 1·9	0·53	1·1	0·6, 1·9	0·77	1·3	0·8, 2·1	0·25	1·0	0·5, 2·3	0·94	1·4	0·8, 2·4	0·23	1·1	0·5, 2·3	0·78
Mother's age (years)																		
<30	Reference			Reference			Reference			Reference			Reference			Reference		
≥30	1·0	0·6, 1·6	0·95	1·1	0·6, 2·1	0·71	1·5	0·9, 2·5	0·08	0·7	0·3, 1·7	0·46	1·1	0·6, 1·9	0·77	0·8	0·4, 1·8	0·62
Mother's education (years)																		
≥12	Reference			Reference			Reference			Reference			Reference			Reference		
9–12	1·4	0·8, 2·5	0·30	1·3	0·7, 2·5	0·46	0·9	0·5, 1·5	0·59	0·6	0·2, 1·5	0·26	1·2	0·6, 2·5	0·58	1·1	0·5, 2·7	0·79
<9	1·2	0·6, 2·3	0·56	1·2	0·6, 2·5	0·65	1·5	0·8, 2·8	0·22	1·5	0·5, 4·1	0·42	1·1	0·5, 2·3	0·84	1·0	0·4, 2·6	0·93
Marital status																		
Married/living together	Reference			Reference			Reference			Reference			Reference			Reference		
Other	1·1	0·5, 2·2	0·89	1·0	0·4, 2·5	0·92	0·6	0·3, 1·3	0·17	0·8	0·2, 2·7	0·73	1·1	0·5, 2·5	0·84	1·4	0·4, 4·6	0·59
Monthly household income (MS)																		
≥3	Reference			Reference			Reference			Reference			Reference			Reference		
<3	1·5	0·9, 2·4	0·08	1·8	1·0, 3·1	0·03	1·3	0·8, 2·1	0·23	1·0	0·5, 2·0	0·96	1·3	0·8, 2·3	0·33	1·3	0·6, 2·6	0·49
Smoking after pregnancy																		
No	Reference			Reference			Reference			Reference			Reference			Reference		
Yes	0·8	0·4, 1·6	0·46	0·9	0·4, 1·9	0·68	1·3	0·7, 2·7	0·39	0·9	0·3, 2·6	0·90	1·2	0·5, 2·6	0·67	1·4	0·5, 3·7	0·48
Pre-pregnancy BMI (kg/m^2)																		
<25·0	Reference			Reference			Reference			Reference			Reference			Reference		
≥25·0	1·2	0·7, 1·8	0·55	1·0	0·6, 1·7	0·86	30·4	15·0, 61·7	<0·01	30·9	13·6, 70·2	<0·01	5·2	2·9, 9·2	<0·01	5·7	2·8, 11·8	<0·01
GWG																		
Adequate	Reference			Reference			Reference			Reference			Reference			Reference		
Excessive	1·6	1·0, 2·5	0·04	1·5	0·9, 2·5	0·14	4·4	2·7, 7·2	<0·01	3·4	1·7, 6·9	<0·01	3·5	2·0, 6·2	<0·01	2·2	1·1, 4·3	0·02
Pregnancies (*n*)																		
2	Reference			Reference			Reference			Reference			Reference			Reference		
3	1·1	0·6, 2·0	0·75	0·9	0·4, 1·4	0·78	2·6	1·4, 4·7	<0·01	1·2	0·5, 3·0	0·75	1·8	0·9, 3·5	0·10	1·1	0·4, 2·6	0·90
≥4	1·0	0·6, 1·7	0·96	0·7	0·3, 1·4	0·28	3·1	1·8, 5·5	<0·01	2·8	1·1, 7·2	0·03	1·4	0·7, 2·8	0·27	0·9	0·4, 2·4	0·86

SGA, small for gestational age; AGA, adequate for gestational age; LGA, large for gestational age; MS, minimum salary ($US 306·00).
*Models 1, 3 and 5: unadjusted.
†Models 2, 4 and 6: adjusted for all covariates listed in Table 3.

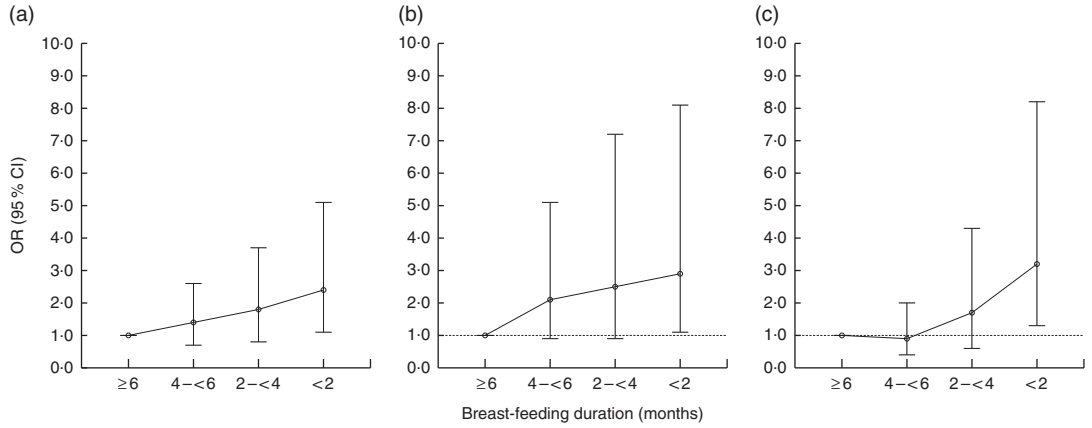

Fig. 2 Risk of excess body weight in (a) children (*n* 305), (b) mothers (*n* 301) and (c) mother–child pairs (*n* 71) by breast-feeding duration, Joinville, Brazil, 2013–2014. Values are odds ratios with their 95 % confidence intervals represented by vertical bars; - - - - - represents the null effect

Parents' behaviours that influence their child's eating habits may override appetite signals[14], eventually contributing to the modification of a child's natural 'self-control'. The second suggested mechanism involves the metabolic consequences of ingesting breast milk[14], which is more energy-dense, more easily metabolized and consumed in smaller amounts compared with formula[53].

Although it is often suggested that the relationship between breast-feeding practices and maternal postpartum weight loss is due to the increased energy demands of breast-feeding, other possible mechanisms may play an important role. For example, high leptin and insulin levels present in mothers at delivery may be one of several possible contributing factors responsible for this increased body weight in the postpartum period in mothers who do not breast-feed. Schubring *et al.*[54] suggested that during late pregnancy and at birth, serum leptin levels are high to help increase energy stores required during delivery and lactation after birth. Serum leptin levels decrease throughout lactation; therefore, mothers who do not breast-feed continue to have higher leptin levels for a longer period of time, which may contribute to an increased body weight compared with those who breast-feed. In addition, elevated leptin and insulin levels in the postpartum period can lead to leptin and insulin resistance, impairing appetite regulation and increasing the risk of obesity[55]. Appetite-regulating hormones like leptin and insulin might also influence infant body composition. Breij *et al.*[56] found higher leptin and insulin levels in infants fed formula for at least 3 months compared with breast-feeding, and both hormones were positively correlated with fat mass percentage.

Presently, many countries around the world, especially emerging economies such as Brazil, are experiencing a nutrition transition[57]. Urbanization and shifts in dietary patterns and levels of physical activity in these countries are fuelling the increased rates of overweight and obesity[57,58]. Therefore, to reduce the global burden of chronic disease, public health strategies focused on primary prevention of obesity early in life and at critical periods throughout the life span, such as during pregnancy and the postpartum period, should be considered.

Early infancy up to age 2 years is a crucial period in a child's development as many obesity-related lifestyle habits are formed at this early stage and unhealthy habits are likely to continue throughout childhood and later in life[10,11,59]. Parents play a critical role in their child's development and make important decisions that affect all aspects of their child's life, including what they eat and consequently their body weight[59]. Therefore, it is important to involve parents in prevention and intervention strategies that target children.

In terms of public health, it is clear that comprehensive efforts should be directed at mothers during the first months after birth so that breast-feeding is indeed acquired. Although mothers attend the prenatal visits, sometimes abandoning or not breast-feeding occurs due to inexperience or even cultural issues. Such features may be circumvented with longer and more effective follow-up after delivery, either through a greater number of paediatrician visits or weekly home visits by health-care professionals.

A major strength of the current study was the analyses of excess body weight concurrently in mother–child pairs, as this type of analysis has not been performed in previous studies. Prospective data collection and the ability to adjust for several important confounding factors are also important strengths of the study. Finally, the same researchers performed data collection, including anthropometric measurements, at baseline and follow-up, therefore reducing possible biases.

A limitation of the present study was the inclusion of self-reported variables, including pre-pregnancy weight, smoking, household income and breast-feeding duration, as such variables are vulnerable to reporter biases. Second, our results are from a relatively small cohort of mothers and their children living in Brazil; therefore, caution should be taken when the results are compared with other

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populations. Although the children in the study were followed only for 2 years, the association between breast-feeding duration and weight status at this age increases our understanding of the impact of breast-feeding during infancy and provides insight into the risk of excess body weight later in life[23]. Lastly, as with most longitudinal studies, a degree of measurement error may have occurred that could have affected the accuracy of both prepartum and postpartum variables used in the study[28].

Conclusions

Unlike previously performed studies, the current investigation concurrently examined the effects of breast-feeding duration on the body weight of mother–child pairs. Findings from the study indicated that breast-feeding for a longer duration has a protective effect on the risk of excess body weight concurrently in both mothers and their children two years after birth. These results are important from a public health perspective as strategies aimed at promoting longer breast-feeding duration could help to attenuate the rising prevalence of overweight and obesity for both mother and child.

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