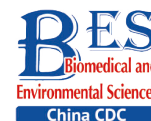


Original Article

**Association of Breastfeeding Duration with Body Composition in Children Aged 3–5 Years***

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Abstract

Objective This study aimed to assess the relationship between the body composition of children aged 3–5 years and breastfeeding status and duration.

Methods The study was conducted using data from the National Nutrition and Health Systematic Survey for children 0–17 years of age in China (CNHSC), a nationwide cross-sectional study. Breastfeeding information and potential confounders were collected using standardized questionnaires administered through face-to-face interviews. The body composition of preschool children was measured using bioelectrical impedance analysis. A multivariate linear regression model was used to assess the relationship between breastfeeding duration and body composition after adjusting for potential confounders.

Results In total, 2,008 participants were included in the study. Of these, 89.2% were ever breastfed and the median duration of breastfeeding was 12 months (IQR 7–15 months). Among children aged 3 years, the height-for-age Z-score (HAZ) for the ever breastfed group was lower than that for never breastfed group (0.12 vs. 0.42, $P = 0.043$). In addition, the weight-for-age Z-score (WAZ) of the ever breastfed group was lower than that of the never breastfed group (0.31 vs. 0.65, $P = 0.026$), and the WAZ was lower in children aged 4 years who breastfed between 12 and 23 months than in those who never breastfed. Compared to the formula-fed children, the fat-free mass of breastfed infants was higher for children aged 3 years (12.84 kg vs. 12.52 kg, $P = 0.015$) and lower for those aged 4 years (14.31 kg vs. 14.64 kg, $P = 0.048$), but no difference was detected for children aged 5 years (16.40 kg vs. 16.42 kg, $P = 0.910$) after adjusting for potential confounders. No significant difference was detected in the weight-for-height Z-score (WHZ), body mass index (BMI)-for-age Z-score (BAZ), fat-free mass index, and body fat indicators in the ever breastfed and never breastfed groups and among various breastfeeding duration groups for children aged 3–5 years.

Conclusion No obvious associations were detected between breastfeeding duration, BMI, and fat mass indicators. Future prospective studies should explore the relationship between breastfeeding status and fat-free mass.

Key words: Breastfeeding; Breastfeeding duration; Bioelectrical impedance analysis; Body composition; Pre-school children

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INTRODUCTION

Breastfeeding is associated with many short- and long-term benefits for infants and their mothers, including improved health and child development. In addition, breastfed individuals have lower risks of obesity and other related chronic diseases, including diabetes, hypertension, hyperlipidemia, cardiovascular disease, and some types of cancer later in life^[1]. Despite its established benefits, the prevalence of exclusive breastfeeding is much lower in China than it is in other middle-income countries^[2]. Given that the causes of breastfeeding are multifactorial, several national ministries and commissions jointly issued the "Breastfeeding Promotion Action Plan 2021–2025" in November 2021, which aimed to provide supportive measures at many levels, from policy directives to social attitudes and values, and health-care services to improve breastfeeding practices in China^[3].

Childhood obesity is a global pandemic. Globally, an estimated 38 million children aged < 5 years were overweight or obese in 2019^[4]. The Chinese National Nutrition and Health Survey (CNNHS) reported that the prevalence of overweight and obesity in children aged < 5 years in 2013 was 8.4% and 3.1%, respectively^[5]. Evidence suggests that obesity could begin in the first 1,000 days of life and become established in preschool years, and that one in five obese children aged four years will suffer from adult obesity^[6-8]. Preventive strategies in early life are effective public health interventions for curbing this pandemic. In October 2020, the National Health Commission, along with five stakeholders, jointly issued the Implementation Plan for Childhood and Adolescent Obesity Prevention and Control, which emphasized the promotion of feeding infants and young children to prevent and control childhood obesity^[9].

Evidence of the protective effect of breastfeeding is more consistent when considering overweight and obesity^[10-12]; in addition, a dose-response relationship with longer breastfeeding duration has been described in some studies^[13-14]. Body composition is significantly different between breastfed and formula-fed infants in the first 2 years of life^[15-17]. However, it remains unknown whether this difference in body composition persists in later years; besides, there are few relevant studies on the topic, especially in China. In addition, there is some evidence that a longer breastfeeding duration is negatively

associated with body fat mass in preschool^[18] and older children^[19-21], although this association is not evident in all studies^[22-24].

Preschool is a pivotal time during which the mechanisms of growth and development are established, with potential lifelong effects on health. However, there are limited studies on the mid- and long-term effects of breastfeeding and breastfeeding duration on more accurate body composition indicators than BMI, which is a surrogate measure of physical growth in Chinese population. Furthermore, it is necessary to provide scientific evidence for infant and young child feeding guidelines to promote scientific feeding practices and prevent and control childhood obesity. The present study aimed to further assess whether body composition at 3–5 years, as measured using bioelectrical impedance analysis (BIA), was related to breastfeeding duration in Chinese children using data from the National Nutrition and Health Systematic Survey for children aged 0–17 years in China in 2019–2020.

METHODS

Participants

This cross-sectional study was conducted between 2019 and 2020. Data were obtained from the National Nutrition and Health Systematic Survey for children 0–17 years of age in China (CNHSC). The study methodology has been previously reported^[25]. We included children aged 3–5 years who were singleton pregnancies and were free of birth defects and other diseases that affect growth (such as cardiovascular diseases, chronic nephritis, tuberculosis, hepatitis, endemic diseases, and chronic bronchitis). Children whose body composition could not be measured using BIA, such as those with epilepsy, were excluded. The participants were from six survey sites in five provinces of China: Taigu County of Jinzhong, Shanxi Province; Dongchang District of Tonghua, and Yongji County, Jilin Province; Qingshan Lake District of Nanchang, Jiangxi Province; Yuelu District of Changsha, Hunan Province; and Longchuan County of Heyuan, Guangdong Province.

This study was approved by the Ethics Review Board of the National Institute for Nutrition and Health, Chinese Center for Disease Control and Prevention (Number: 2019-009). Written informed consent was obtained from each child's caregiver prior to the survey.

Infant Feeding Practice

Data on feeding practices during children first 2 years were collected through face-to-face interviews with the caregivers of the children, most of whom were mothers. Data on the breastfeeding status and weaning time were collected. On this basis, breastfeeding duration was calculated and divided into six feeding groups: never breastfed, breastfed for < 4 months, breastfed for 4–5 months, breastfed for 6–11 months, breastfed for 12–23 months, and breastfed for ≥ 24 months.

Anthropometric Measurement and Body Composition Assessment

The weight was measured in light clothing and height was measured without footwear; BIA assessment was performed immediately after. Measurements were performed once by a trained examiner, using uniform instruments. At least one quality control staff member was appointed to conduct on-site supervision to ensure the accuracy and standardization of the measurement methods. Based on these results, z-scores were calculated using the least mean square (LMS) method based on the WHO Growth and Development Standards^[26-27]. The height-for-age Z-score (HAZ), weight-for-age Z-score (WAZ), weight-for-height Z-score (WHZ), and BMI-for-age Z-score (BAZ) were calculated using the formula $Z = [(X/M)^L - 1]/(S \times L)$, where X indicates anthropometric data, such as height and weight of the children. The LMS method is based on the Box-Cox normal transformation, and the parameters L , M , and S represent the Box-Cox conversion powers, median of the growth standard, and coefficients of variation, respectively. Stunting was defined as HAZ < -2 (HAZ of children below two standard deviations of the median height of growth standards). Underweight participants were defined as WAZ < -2. For children aged 3 and 4 years, WHZ < -2 was defined as wasting, $2 < WHZ \leq 3$ overweight, and $WHZ > 3$ obesity. For children aged 5 years, BAZ < -2 was defined as wasting, $1 < BAZ \leq 2$ overweight, and $BAZ > 2$ obesity.

A bioelectrical impedance analysis device (InBody 770 body composition analyzer, South Korea) was used to measure total fat-free mass, body fat mass, and percentage of body fat in children aged 3–5 years. Measurement was taken in the morning, with the participants fasting and wearing light clothing, after emptying the bladder and bowels, and after a 2 h break from intense physical activity. During the analysis, it was ensured that the test child had bare and clean hands and feet that were properly

positioned on the handles or platform and were in contact with the electrodes. Children whose body composition could not be measured using BIA, such as children with epilepsy or those with electronic devices inside their bodies, were excluded. Height-adjusted indices were calculated because fat mass and fat-free mass depend on height. We used height raised to a power of 2 to calculate the fat mass index [body fat mass (kg)/height (m)²], and height raised to a power of 2.5 to calculate the fat-free mass index [fat-free mass (kg)/height (m)^{2.5}]^[18].

Potential Confounders

The following potential confounders were obtained: age, gender, birth weight, residential area, eating behavior score (calculated according to the dietary behavior questionnaire over the past month; the higher the score, the less healthy the children's eating behavior), diet quality distance score, middle/high-level physical activity time per day (categorized as < 60 min and > 60 min based on Exercise Guide for Preschoolers in China^[28]), and nocturnal sleep time (the average time of nocturnal sleep per day over the past week, in hours). Parental BMI (categorized as underweight [BMI < 18.5 kg/m²], normal [18.5–23.9 kg/m²], overweight [24.0–27.9 kg/m²], and obesity [≥ 28.0 kg/m²], according to categorization of BMI in adults in China issued in 2013^[29]) and parental education level (four categories, including junior high school or below, high school, associate's degree, and bachelor's degree or above) was collected using a household questionnaire.

The diet quality distance (DQD) score is an indicator of the Chinese diet balance index for preschool children^[30] and was calculated using food intake data collected by a food frequency questionnaire over the past week and referred to the Chinese Dietary Guidelines for preschool children^[31]. The DQD ranges from 0 to 60 points and provides a comprehensive picture of dietary imbalances. A score of 0 indicates that the diet is balanced; 1–12 points mean that the diet is appropriate; 13–24 points are classified as low-degree dietary imbalance; 25–36 points and ≥ 37 points indicate that the diet is moderate and high-degree dietary imbalance, respectively.

Statistical Analysis

Approximately normally distributed data such as height, Z score, fat-free mass, and body fat percentage of children were expressed as means and standard deviations.

Student's *t*-test and analysis of variance (ANOVA) were used to compare the mean values for each group. Non-normally distributed data, such as total body weight, BMI, and body fat mass, were expressed as interquartile range (IQR), and Student's *t*-test and ANOVA were used to compare the means of each group after logarithmic transformation. The chi-squared test was used to compare the differences between categorical variables.

Total fat-free mass, fat-free mass index, fat mass, fat mass index, and body fat percentage were included in the general linear model as continuous variables. Gender was adjusted to control for variations caused by the normal growth and development of boys and girls. Breastfeeding status and duration at infancy were analyzed as categorical variables and compared with the reference group. A regression model was used to calculate the mean value of each indicator of body composition after adjusting for potential confounders. For residual normal data such as fat-free mass, fat-free mass index, and percentage of body fat, the mean, mean difference, and 95% confidence interval (CI) were the original values in the regression analysis. In contrast, for fat mass and fat mass index, whose residual values were normal after logarithmic transformation, the mean, mean difference, and 95% CI were antilog results after logarithmic transformation. All data were analyzed using SAS (version 9.4; SAS Institute Inc., Cary, NC, USA). Statistical tests were two-sided, and a *P* value < 0.05 was considered statistically significant.

RESULTS

Characteristics of the Participants

Overall, 2008 participants were included in the analysis, and the numbers of children aged 3, 4, and 5 years were 642, 700, and 666, respectively (Figure 1). The characteristics of the children and their parents are presented in Table 1. Approximately 89.2% of the children were ever breastfed and the median duration of breastfeeding was 12 months (IQR, 7–15 months). As the children grew, their height, weight, total body water, fat mass, and fat-free mass gradually increased (all *P* < 0.001; Table 2). Body composition indicators were stratified by age for subsequent analyses.

Relationship between Breastfeeding Duration and HAZ, WAZ, and WHZ/BAZ

After adjusting for gender, birth weight, survey

sites, nocturnal sleep time, middle- and high-level physical activity time, eating behavior score, balanced diet index score, parental BMI, and education level, HAZ was lower in ever breastfed children than in never breastfed children (0.12 vs. 0.42, *F* = 4.14, *P* = 0.043) at 3 years of age (Table 3). In addition, WAZ was lower in ever breastfed children than in never breastfed children (0.31 vs. 0.65, *F* = 4.99, *P* = 0.026) at 4 years of age. The difference in the WAZ for different breastfeeding durations was statistically significant (*F* = 2.43, *P* = 0.034), and the WAZ was lower in children who breastfed for 12–23 months than in those who never breastfed (0.21 vs. 0.66) among children aged 4 years. No statistically significant difference in WHZ/BAZ was observed among children with different breastfeeding durations (Table 4).

Association between Breastfeeding Duration and Fat Free Mass

After adjusting for gender, birth weight, survey sites, HAZ (fat-free mass index was not adjusted by HAZ), nocturnal sleep time, middle- and high-level physical activity time, eating behavior score, balanced diet index score, parental BMI, and education level, there were no significant differences in fat-free mass index among the ever breastfed and never breastfed groups and different breastfeeding duration groups for children aged 3–5 years (Table 5).

After adjusting for potential confounders, the fat-free mass of ever breastfed infants was higher than that of never breastfed infants (12.84 kg vs. 12.52 kg, *F* = 5.91, *P* = 0.015) among children aged 3 years, and was lower (14.31 kg vs. 14.64 kg, *F* = 3.92, *P* = 0.048) among children aged 4 years. No

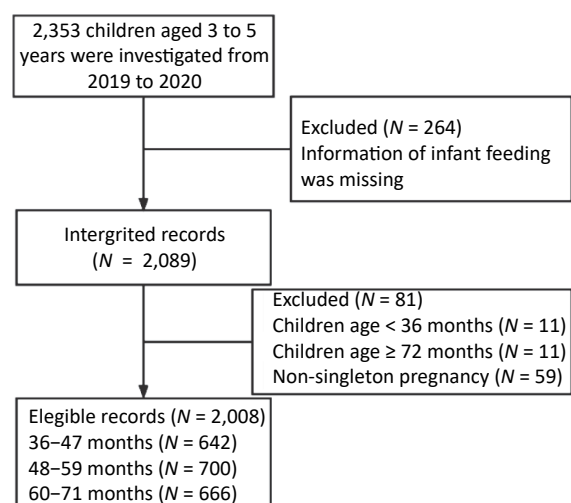


Figure 1. Flowchart of study participants.

Table 1. Characteristics of children and parents

		Continued	
Characteristics	N (%) or Mean \pm SD	Characteristics	N (%) or Mean \pm SD
Children		Breastfeeding	
Age groups (years)		Never	10.8 (217/2,007)
3	32.0 (642/2,008)	Ever	89.2 (1,790/2,007)
4	34.8 (700/2,008)	Duration of breastfeeding (months)	
5	33.2 (666/2,008)	Never	11.2 (217/1,931)
Gender		< 4	11.4 (221/1,931)
Boy	50.2 (1,008/2,008)	4–	3.6 (69/1,931)
Girl	49.8 (1,000/2,008)	6–	28.4 (548/1,931)
Residential area		12–	41.4 (800/1,931)
Urban	54.9 (1,102/2,008)	\geq 24	3.9 (76/1,931)
Rural	45.1 (906/2,008)	Middle/high-level physical activity time (min)	
Region		\geq 60	81.0 (1,467/1,811)
North	55.1 (1,106/2,008)	< 60	19.0 (344/1,811)
South	44.9 (902/2,008)	Nocturnal sleep time (hours)	9.5 \pm 0.6
Survey site		Eating behavior scores	19.2 \pm 3.4
Taigu County	18.0 (362/2,008)	Diet quality distance (scores)	22.6 \pm 8.9
Jichang District	17.9 (360/2,008)	Parents	
Yongji County	19.1 (384/2,008)	Maternal BMI (kg/m²)	
Qingshan Lake District	17.6 (354/2,008)	Underweight	9.4 (180/1,912)
Yuelu District	19.4 (388/2,008)	Normal	72.2 (1,381/1,912)
Longchuan County	8.0 (160/2,008)	Overweight	15.1 (288/1,912)
Annual household income (per capita CNY [*])		Obesity	3.3 (63/1,912)
< 10,000	4.2 (85/2,004)	Maternal education	
10,000–	7.3 (146/2,004)	Junior high school or below	27.0 (537/1,988)
\geq 20,000	12.2 (245/2,004)	High school	18.5 (368/1,988)
Refusal to answer	41.3 (828/2,004)	Associate's degree	22.6 (450/1,988)
Unknown	34.9 (700/2,004)	Bachelor's degree or above	31.8 (633/1,988)
Birth weight (g)		Father's BMI (kg/m²)	
< 2,500	2.6 (47/1,814)	Underweight	3.0 (56/1,868)
2,500–4,000	90.7 (1,645/1,814)	Normal	56.6 (1,057/1,868)
> 4,000	6.7 (122/1,814)	Overweight	33.3 (622/1,868)
Gestational age		Obesity	7.1 (133/1,868)
pre-term	4.6 (92/1,997)	Father's education	
Term	95.4 (1,905/1,997)	Junior high school or below	29.1 (580/1,996)
Nutrition status		High school	19.5 (390/1,996)
Stunting	1.1 (22/2,008)	Associate's degree	19.9 (397/1,996)
Wasting	1.7 (34/2,008)	Bachelor's degree or above	31.5 (629/1,996)
Underweight	0.8 (17/2,008)		
Overweight or obesity	9.6 (193/2,008)		

Note. * CNY: Chinese Yuan.

statistically significant difference was observed between the two groups in children aged 5 years.

For children aged 3 and 4 years, there was no statistically significant difference in fat-free mass among those with different breastfeeding durations after adjusting for potential confounders.

For children aged 5 years, the overall difference in fat-free mass ($F = 4.09$, $P = 0.001$) among children with different breastfeeding durations was statistically significant. However, there were no significant differences between the different breastfeeding duration groups and the reference group (never breastfed).

Association of Breastfeeding Duration with Body Fat Mass

After adjusting for potential confounders, there was no statistically significant difference in body fat indicators between the ever breastfed and never breastfed groups and the different breastfeeding duration groups for children aged 3–5 years (Tables 6–7).

DISCUSSION

In the present study, no significant associations

were detected between fat mass, fat mass index, and fat percentage in children age 3–5 years and breastfeeding status or duration. Although fat-free mass was higher in ever breastfed children than in never breastfed children at 3 years of age and lower at 4 years of age, the difference was eliminated at 5 years of age. After adjusting for potential confounders, there was no significant association between fat-free mass index and breastfeeding status or duration of breastfeeding in children aged 3–5 years.

Association of Breastfeeding and Duration of Breastfeeding with Anthropometric Status

In the present study, we found that, compared with the never breastfed group, the HAZ of the ever breastfed group was lower among children aged 3 years, and the WAZ of the ever breastfed group was lower among children aged 4 years. However, consistent with findings from earlier studies^[18,23], we found that there was no difference in WHZ/BAZ between breastfed and non-breastfed children aged 3–5 years. The Promotion of Breastfeeding Intervention Trial (PROBIT) showed that breastfeeding promotion intervention resulted in substantial increases in breastfeeding duration and

Table 2. Status of body composition and anthropometric measurements for children aged 3 to 5 years

Variables	Total		3 years		4 years		5 years	
	<i>n</i>	<i>M</i> (IQR) or Mean \pm SD	<i>n</i>	<i>M</i> (IQR) or Mean \pm SD	<i>n</i>	<i>M</i> (IQR) or Mean \pm SD	<i>n</i>	<i>M</i> (IQR) or Mean \pm SD
Body composition								
Total body water (kg)	2,007	10.8 \pm 1.7	641	9.5 \pm 1.1	700	10.7 \pm 1.3	666	12.2 \pm 1.5
Total fat-free mass (kg)	1,999	14.6 \pm 2.3	641	12.8 \pm 1.5	700	14.6 \pm 1.7	658	16.5 \pm 1.9
Fat-free mass index (kg/m ^{2.5})	1,999	12.3 \pm 0.8	641	12.8 \pm 0.8	700	12.3 \pm 0.7	658	11.9 \pm 0.7
Total body fat mass (kg)	1,968	3.0 (2.4, 4.0)	632	2.7 (2.1, 3.5)	693	3.2 (2.5, 4.0)	643	3.3 (2.6, 4.5)
Fat mass index (kg/m ²)	1,968	2.7 (2.1, 3.5)	632	2.7 (2.2, 3.4)	693	2.8 (2.2, 3.5)	643	2.6 (2.1, 3.5)
Percentage body fat (%)	1,968	18.2 \pm 5.5	632	18.1 \pm 5.1	693	18.6 \pm 5.5	643	18.1 \pm 6.0
Anthropometric status*								
Height (cm)	2,008	107.1 \pm 7.4	642	99.9 \pm 4.6	700	107.1 \pm 4.9	666	114.0 \pm 4.9
Weight (kg)	2,002	17.4 (15.6, 19.6)	642	15.3 (14.2, 16.6)	700	17.5 (16.0, 19.3)	660	19.6 (18.0, 22.1)
BMI (kg/m ²)	2,002	15.4 (14.6, 16.3)	642	15.4 (14.7, 16.2)	700	15.4 (14.6, 16.3)	660	15.3 (14.5, 16.5)
WAZ	2,002	0.2 \pm 1.1	642	0.1 \pm 1.0	700	0.2 \pm 1.0	660	0.3 \pm 1.2
HAZ	2,008	0.2 \pm 1.0	642	0.1 \pm 1.0	700	0.1 \pm 1.0	666	0.3 \pm 1.0
WHZ	1,342	0.1 \pm 1.0	642	0.1 \pm 1.0	700	0.1 \pm 1.0	/	/
BAZ	2,002	0.1 \pm 1.1	642	0.1 \pm 1.0	700	0.2 \pm 1.0	660	0.2 \pm 1.3

Note. * HAZ: Height-for-age Z-score, WAZ: Weight-for-age Z-score, WHZ: Weight-for-height Z-score, BAZ: BMI-for-age Z-score.

Table 3. Relationship between breastfeeding duration and HAZ and WAZ of participants stratified by age

Variables	n	Height-for-age Z-score (HAZ)				Weight-for-age Z-score (WAZ)			
		Adjusted*	Difference (95% CI)	Adjusted**	Difference (95% CI)	Adjusted*	Difference (95% CI)	Adjusted**	Difference (95% CI)
Children aged 3 years									
Breastfeeding	642								
Never	72	0.27	Referent	0.42	Referent	0.15	Referent	0.25	Referent
Ever	570	0.12	-0.15 (-0.41, 0.10)	0.12	-0.30 (-0.58, -0.01)	0.14	0 (-0.25, 0.24)	0.21	-0.03 (-0.30, 0.23)
F value		1.46		4.14		0		0.06	
P value		0.228		0.043		0.969		0.799	
Breastfeeding duration (months)	623								
Never	72	0.27	Referent	0.41	Referent	0.15	Referent	0.24	Referent
< 4	68	0	-0.27 (-0.71, 0.16)	-0.03	-0.43 (-0.94, 0.08)	0.13	-0.02 (-0.44, 0.40)	0.27	0.03 (-0.44, 0.49)
4–	17	0.66	0.39 (-0.31, 1.08)	0.38	-0.02 (-0.81, 0.76)	0.50	0.36 (-0.32, 1.03)	0.32	0.07 (-0.65, 0.79)
6–	174	0.21	-0.06 (-0.42, 0.30)	0.23	-0.18 (-0.60, 0.25)	0.18	0.03 (-0.32, 0.38)	0.24	0 (-0.39, 0.39)
12–	266	0.03	-0.24 (-0.59, 0.10)	0.05	-0.36 (-0.76, 0.05)	0.07	-0.07 (-0.40, 0.26)	0.19	-0.06 (-0.43, 0.31)
≥ 24	26	0.16	-0.12 (-0.70, 0.47)	-0.29	-0.69 (-1.41, 0.03)	0.34	0.20 (-0.37, 0.77)	-0.08	-0.33 (-0.99, 0.34)
F value		2.15		2.19		0.96		0.44	
P value		0.058		0.054		0.440		0.819	
Children aged 4 years									
Breastfeeding	699								
Never	71	0.38	Referent	0.40	Referent	0.46	Referent	0.65	Referent
Ever	628	0.10	-0.28 (-0.51, -0.04)	0.12	-0.28 (-0.58, 0.01)	0.15	-0.31 (-0.55, -0.07)	0.31	-0.34 (-0.64, -0.04)
F value		5.21		3.60		6.22		4.99	
P value		0.023		0.058		0.013		0.026	
Breastfeeding duration (months)	663								
Never	71	0.38	Referent	0.41	Referent	0.46	Referent	0.66	Referent
< 4	80	0.21	-0.17 (-0.56, 0.22)	0.29	-0.12 (-0.60, 0.35)	0.21	-0.25 (-0.65, 0.15)	0.44	-0.22 (-0.70, 0.26)
4–	24	0.10	-0.28 (-0.85, 0.29)	0.14	-0.28 (-0.93, 0.37)	0.15	-0.31 (-0.89, 0.28)	0.29	-0.37 (-1.03, 0.29)
6–	196	0.16	-0.22 (-0.55, 0.12)	0.23	-0.18 (-0.60, 0.24)	0.20	-0.26 (-0.60, 0.08)	0.48	-0.18 (-0.61, 0.24)
12–	264	0.07	-0.30 (-0.62, 0.02)	0.03	-0.38 (-0.78, 0.02)	0.15	-0.31 (-0.64, 0.02)	0.21	-0.45 (-0.85, -0.05)
≥ 24	28	0.10	-0.27 (-0.81, 0.26)	-0.06	-0.47 (-1.09, 0.14)	0.13	-0.33 (-0.88, 0.22)	0.14	-0.52 (-1.15, 0.10)
F value		1.23		1.84		1.18		2.43	
P value		0.292		0.105		0.315		0.034	
Children aged 5 years									
Breastfeeding	666								
Never	74	0.48	Referent	0.40	Referent	0.53	Referent	0.33	Referent
Ever	592	0.32	-0.16 (-0.39, 0.06)	0.34	-0.06 (-0.35, 0.24)	0.13	-0.22 (-0.49, 0.06)	0.34	0.02 (-0.34, 0.37)
F value		1.96		0.14		2.46		0.01	
P value		0.162		0.709		0.117		0.925	

Continued

Variables	n	Height-for-age Z-score (HAZ)				Weight-for-age Z-score (WAZ)			
		Adjusted*	Difference (95% CI)	Adjusted**	Difference (95% CI)	Adjusted*	Difference (95% CI)	Adjusted**	Difference (95% CI)
Breastfeeding duration (months)	645								
Never	74	0.48	Referent	0.40	Referent	0.53	Referent	0.36	Referent
< 4	73	0.51	0.03 (-0.36, 0.42)	0.67	0.27 (-0.22, 0.75)	0.37	-0.16 (-0.63, 0.31)	0.64	0.28 (-0.30, 0.87)
4-	28	0.42	0.06 (-0.59, 0.46)	0.42	0.01 (-0.60, 0.63)	0.53	0 (-0.64, 0.63)	0.68	0.32 (-0.42, 1.06)
6-	178	0.35	-0.13 (-0.46, 0.19)	0.39	-0.01 (-0.44, 0.41)	0.28	-0.26 (-0.65, 0.14)	0.25	-0.10 (-0.62, 0.41)
12-	270	0.22	-0.27 (-0.58, 0.04)	0.25	-0.15 (-0.55, 0.24)	0.29	-0.25 (-0.62, 0.13)	0.34	-0.02 (-0.49, 0.46)
≥ 24	22	0.41	-0.07 (-0.65, 0.50)	0.39	-0.01 (-0.67, 0.65)	0.16	-0.37 (-1.07, 0.32)	0.23	-0.13 (-0.92, 0.67)
F value		1.82		1.69		0.92		1.28	
P value		0.106		0.135		0.470		0.273	

Note. * Mean value after adjusting for gender. ** Mean values after adjusting for gender, birth weight, survey site, nocturnal sleep time, middle- and high-level physical activity time, eating behavior score, balanced diet index score, parental BMI, and education level.

Table 4. Relationship between breastfeeding duration and WHZ or BAZ of participants stratified by age

Variables	n	Weight-for-height Z-score (WHZ) or BMI-for-age Z-score (BAZ)			
		Adjusted*	Difference (95% CI)	Adjusted**	Difference (95% CI)
Children aged 3 years					
Breastfeeding	642				
Never	72	-0.02	Referent	0.001	Referent
Ever	570	0.11	-0.08	0.21	0.21 (-0.07, 0.49)
F value		1.00	0.13 (-0.12, 0.37)	2.08	
P value		0.317		0.150	
Breastfeeding duration (months)	623				
Never	72	-0.02	Referent	0.01	Referent
< 4	68	0.19	0.21 (-0.22, 0.64)	0.42	0.42 (-0.08, 0.91)
4-	17	0.19	0.21 (-0.48, 0.89)	0.14	0.13 (-0.63, 0.89)
6-	174	0.08	0.10 (-0.26, 0.45)	0.16	0.15 (-0.26, 0.56)
12-	266	0.09	0.37 (-0.21, 0.95)	0.22	0.22 (-0.17, 0.61)
≥ 24	26	0.35		0.10	0.09 (-0.61, 0.80)
F value		0.70		1.03	
P value		0.626		0.399	
Children aged 4 years					
Breastfeeding	699				
Never	71	0.28	Referent	0.55	Referent
Ever	628	0.10	-0.18 (-0.43, 0.07)	0.32	-0.23 (-0.54, 0.09)
F value		2.09		1.94	
P value		0.149		0.164	
Breastfeeding duration (months)	663				
Never	71	0.28	Referent	0.56	Referent

Continued

Variables	n	Weight-for-height Z-score (WHZ) or BMI-for-age Z-score (BAZ)			
		Adjusted*	Difference (95% CI)	Adjusted**	Difference (95% CI)
< 4	80	0.10	-0.19 (-0.60, 0.23)	0.37	-0.20 (-0.71, 0.32)
4-	24	0.09	-0.19 (-0.80, 0.41)	0.27	-0.29 (-1.00, 0.42)
6-	196	0.12	-0.17 (-0.52, 0.19)	0.47	-0.09 (-0.54, 0.37)
12-	264	0.12	-0.16 (-0.51, 0.18)	0.26	-0.30 (-0.74, 0.13)
≥ 24	28	0.05	-0.23 (-0.81, 0.34)	0.22	-0.34 (-1.01, 0.33)
F value		0.39		1.10	
P value		0.856		0.361	
Children aged 5 years					
Breastfeeding	666				
Never	74	0.31	Referent	0.08	Referent
Ever	592	0.14	-0.17 (-0.47, 0.13)	0.17	0.09 (-0.30, 0.49)
F value		1.26		0.21	
P value		0.262		0.649	
Breastfeeding duration (months)	645				
Never	74	0.32	Referent	0.12	Referent
< 4	73	0.08	-0.24 (-0.76, 0.27)	0.33	0.21 (-0.44, 0.86)
4-	28	0.40	0.08 (-0.61, 0.77)	0.62	0.50 (-0.32, 1.33)
6-	178	0.07	-0.25 (-0.68, 0.18)	-0.01	-0.13 (-0.70, 0.44)
12-	270	0.20	-0.12 (-0.53, 0.29)	0.25	0.13 (-0.40, 0.66)
≥ 24	22	-0.23	-0.55 (-1.30, 0.21)	-0.12	-0.24 (-1.13, 0.64)
F value		1.21		1.58	
P value		0.301		0.166	

Note. * Mean value after adjusting for gender. ** Mean value after adjusting for gender, birthweight, survey site, nocturnal sleep time, middle- and high-level physical activity time, eating behavior score, balanced diet index score, parental BMI, and education level.

Table 5. Relationship between breastfeeding status and fat-free mass and fat-free mass index of children stratified by age

Variables	n	Fat-free mass, kg				Fat-free mass index, kg/m ^{2.5}			
		Adjusted*	Difference (95% CI)	Adjusted**	Difference (95% CI)	Adjusted*	Difference (95% CI)	Adjusted**	Difference (95% CI)
Children aged 3 years									
Breastfeeding	641								
Never	71	12.72	Referent	12.52	Referent	12.70	Referent	12.62	Referent
Ever	570	12.75	0.03 (-0.32, 0.38)	12.84	0.32 (0.06, 0.59)	12.75	0.05 (-0.14, 0.24)	12.76	0.14 (-0.09, 0.37)
F value		0.03		5.91		0.31		1.50	
P value		0.868		0.015		0.580		0.222	
Breastfeeding duration (months)	622								
Never	71	12.72	Referent	12.51	Referent	12.70	Referent	12.63	Referent
< 4	68	12.76	0.03 (-0.57, 0.64)	12.98	0.46 (0.01, 0.92)	12.74	0.04 (-0.29, 0.37)	12.83	0.21 (-0.19, 0.61)
4-	17	13.62	0.89 (-0.07, 1.86)	13.06	0.54 (-0.16, 1.24)	12.74	0.04 (-0.49, 0.56)	12.70	0.07 (-0.54, 0.69)

Continued

Variables	n	Fat-free mass, kg				Fat-free mass index, kg/m ^{2.5}			
		Adjusted*	Difference (95% CI)	Adjusted**	Difference (95% CI)	Adjusted*	Difference (95% CI)	Adjusted**	Difference (95% CI)
6–	174	12.85	0.13 (-0.37, 0.63)	12.85	0.33 (-0.05, 0.71)	12.74	0.04 (-0.23, 0.31)	12.74	0.11 (-0.22, 0.44)
12–	266	12.63	-0.10 (-0.58, 0.38)	12.85	0.33 (-0.03, 0.69)	12.77	0.07 (-0.18, 0.33)	12.81	0.19 (-0.13, 0.51)
≥ 24	26	12.76	0.03 (-0.78, 0.85)	12.57	0.06 (-0.59, 0.71)	12.77	0.08 (-0.37, 0.52)	12.74	0.12 (-0.45, 0.68)
F value		1.88		1.94		0.13		0.59	
P value		0.096		0.086		0.986		0.711	
Children aged 4 years									
Breastfeeding	699								
Never	71	15.20	Referent	14.64	Referent	12.25	Referent	12.17	Referent
Ever	628	14.49	-0.71 (-1.12, -0.30)	14.31	-0.33 (-0.66, -0.003)	12.25	-0.004 (-0.17, 0.16)	12.13	-0.04 (-0.26, 0.18)
F value		11.79		3.92		0.00		0.12	
P value		< 0.001		0.048		0.960		0.728	
Breastfeeding duration (months)	663								
Never	71	15.19	Referent	14.64	Referent	Referent	Referent	12.17	Referent
< 4	80	14.53	-0.67 (-1.34, 0.01)	14.29	-0.34 (-0.87, 0.19)	12.25	-0.04 (-0.32, 0.24)	12.15	-0.01 (-0.38, 0.33)
4–	24	14.71	-0.49 (-1.46, 0.49)	14.59	-0.04 (-0.77, 0.69)	12.22	0.08 (-0.32, 0.49)	12.21	0.04 (-0.45, 0.53)
6–	196	14.57	-0.62 (-1.19, -0.04)	14.30	-0.33 (-0.80, 0.13)	12.34	0.001 (-0.24, 0.24)	12.17	-0.003 (-0.32, 0.31)
12–	264	14.46	-0.73 (-1.29, -0.18)	14.26	-0.37 (-0.82, 0.07)	12.26	0.004 (-0.23, 0.23)	12.08	-0.09 (-0.39, 0.21)
≥ 24	28	14.69	-0.51 (-1.43, 0.42)	14.48	-0.16 (-0.85, 0.53)	12.26	0.001 (-0.38, 0.39)	12.17	0.004 (-0.46, 0.47)
F value		2.30		1.24		0.13		0.31	
P value		0.044		0.290		0.986		0.908	
Children aged 5 years									
Breastfeeding	658								
Never	74	16.91	Referent	16.42	Referent	11.96	Referent	11.81	Referent
Ever	584	16.46	-0.45 (-0.87, -0.02)	16.40	-0.01 (-0.37, 0.33)	11.90	-0.06 (-0.22, 0.10)	11.87	0.06 (-0.15, 0.28)
F value		4.24		0.01		0.55		0.36	
P value		0.040		0.914		0.459		0.547	
Breastfeeding duration (months)	637								
Never	74	16.91	Referent	16.48	Referent	11.97	Referent	11.83	Referent
< 4	72	16.79	-0.12 (-0.86, 0.61)	16.52	0.04 (-0.52, 0.61)	11.92	-0.05 (-0.32, 0.23)	11.91	0.08 (-0.27, 0.42)
4–	27	16.43	-0.48 (-1.48, 0.51)	16.31	-0.16 (-0.87, 0.54)	11.87	-0.09 (-0.47, 0.28)	11.84	0.01 (-0.43, 0.44)
6–	174	16.31	-0.61 (-1.22, 0.01)	16.08	-0.40 (-0.89, 0.09)	11.87	-0.10 (-0.33, 0.13)	11.73	-0.11 (-0.41, 0.20)
12–	268	16.45	-0.46 (-1.04, 0.12)	16.64	0.16 (-0.29, 0.62)	11.94	-0.03 (-0.25, 0.19)	11.97	0.14 (-0.14, 0.42)
≥ 24	22	16.19	-0.72 (-1.79, 0.35)	16.14	-0.33 (-1.10, 0.43)	11.76	-0.21 (0.61, 0.20)	11.85	0.02 (-0.45, 0.49)
F value		1.80		4.09		0.62		1.96	
P value		0.110		0.001		0.684		0.083	

Note. * Mean value after adjusting for gender. ** Mean value after adjusting for gender, birthweight, survey site, nocturnal sleep time, middle-and high-level physical activity time, eating behavior score, balanced diet index score, parental BMI, and education level. HAZ was also adjusted for fat-free mass.

Table 6. Relationship between breastfeeding status and body fat mass, and fat mass index

Variables	n	Body fat mass, kg				Body fat mass index, kg/m ²			
		Adjusted*	Difference (95% CI)	Adjusted**	Difference (95% CI)	Adjusted*	Difference (95% CI)	Adjusted**	Difference (95% CI)
Children aged 3 years									
Breastfeeding	632								
Never	72	2.76	Referent	2.75	Referent	2.77	Referent	2.73	Referent
Ever	560	2.71	0.98 (0.90, 1.07)	2.79	1.02 (0.91, 1.12)	2.72	0.98 (0.90, 1.10)	2.80	1.03 (0.93, 1.13)
F value		0.18		0.08		0.16		0.26	
P value		0.669		0.771		0.690		0.608	
Breastfeeding duration (months)	613								
Never	72	2.76	Referent	2.74	Referent	2.77	Referent	2.73	Referent
< 4	68	2.78	1.01 (0.86, 1.18)	2.92	1.07 (0.89, 1.27)	2.79	1.01 (0.87, 1.17)	2.95	1.08 (0.91, 1.29)
4–	16	2.86	1.03 (0.80, 1.34)	2.83	1.03 (0.78, 1.37)	2.72	0.98 (0.77, 1.26)	2.76	1.01 (0.77, 1.33)
6–	172	2.73	0.99 (0.87, 1.13)	2.80	1.02 (0.88, 1.19)	2.72	0.98 (0.87, 1.11)	2.78	1.02 (0.88, 1.18)
12–	264	2.69	0.97 (0.86, 1.10)	2.73	1.00 (0.87, 1.15)	2.72	0.98 (0.87, 1.11)	2.77	1.01 (0.88, 1.17)
≥ 24	21	2.44	0.88 (0.70, 1.11)	2.67	0.97 (0.75, 1.27)	2.53	0.91 (0.73, 1.14)	2.83	1.04 (0.80, 1.34)
F value		0.54		0.31		0.28		0.32	
P value		0.750		0.909		0.926		0.899	
Children aged 4 years									
Breastfeeding	692								
Never	68	3.31	Referent	3.46	Referent	2.81	Referent	2.92	Referent
Ever	624	3.16	0.95 (0.86, 1.05)	3.18	0.92 (0.81, 1.04)	2.77	0.98 (0.90, 1.08)	2.78	0.95 (0.85, 1.07)
F value		0.90		1.69		0.10		0.64	
P value		0.344		0.194		0.749		0.425	
Breastfeeding duration (months)	656								
Never	68	3.31	Referent	3.49	Referent	2.81	Referent	2.94	Referent
< 4	78	3.26	0.98 (0.83, 1.16)	3.35	0.96 (0.79, 1.18)	2.86	1.02 (0.87, 1.19)	2.93	0.99 (0.82, 1.20)
4–	24	3.11	0.94 (0.74, 1.19)	3.04	0.87 (0.66, 1.14)	2.71	0.96 (0.77, 1.21)	2.63	0.89 (0.69, 1.15)
6–	195	3.2	0.97 (0.84, 1.11)	3.30	0.95 (0.79, 1.13)	2.80	0.99 (0.87, 1.13)	2.85	0.97 (0.82, 1.14)
12–	263	3.11	0.94 (0.82, 1.08)	3.13	0.9 (0.76, 1.06)	2.74	0.97 (0.86, 1.11)	2.75	0.94 (0.80, 1.10)
≥ 24	28	3.16	0.95 (0.76, 1.19)	3.11	0.89 (0.69, 1.15)	2.75	0.98 (0.79, 1.21)	2.74	0.93 (0.73, 1.18)
F value		0.37		0.86		0.22		0.57	
P value		0.869		0.507		0.952		0.724	
Children aged 5 years									
Breastfeeding	643								
Never	71	3.48	Referent	3.22	Referent	2.66	Referent	2.46	Referent
Ever	572	3.42	0.98 (0.88, 1.09)	3.54	1.1 (0.96, 1.26)	2.65	1.00 (0.90, 1.10)	2.73	1.11 (0.97, 1.26)

Continued

Variables	n	Body fat mass, kg				Body fat mass index, kg/m ²			
		Adjusted*	Difference (95% CI)	Adjusted**	Difference (95% CI)	Adjusted*	Difference (95% CI)	Adjusted**	Difference (95% CI)
F value		0.10		1.81		0.01		2.39	
P value		0.747		0.180		0.929		0.123	
Breastfeeding duration (months)	623								
Never	71	3.49	Referent	3.24	Referent	2.66	Referent	2.48	Referent
< 4	70	3.14	0.90 (0.75, 1.08)	3.46	1.07 (0.85, 1.35)	2.41	0.9 (0.76, 1.07)	2.61	1.06 (0.85, 1.31)
4–	26	3.83	1.10 (0.86, 1.41)	4.22	1.30 (0.98, 1.73)	2.96	1.11 (0.88, 1.4)	3.24	1.31 (1.00, 1.72)
6–	175	3.39	0.97 (0.83, 1.13)	3.42	1.05 (0.86, 1.29)	2.63	0.99 (0.85, 1.14)	2.64	1.07 (0.88, 1.29)
12–	259	3.49	1.00 (0.87, 1.16)	3.55	1.09 (0.91, 1.32)	2.71	1.02 (0.89, 1.17)	2.74	1.11 (0.93, 1.32)
≥ 24	22	3.43	0.98 (0.76, 1.28)	3.73	1.15 (0.84, 1.57)	2.66	1.00 (0.78, 1.28)	2.89	1.17 (0.87, 1.56)
F value		1.04		1.29		1.33		1.54	
P value		0.391		0.269		0.251		0.175	

Note. Regression analyses of body fat mass and body fat mass index were conducted after logarithmic transformation, and the antilog of the mean difference after logarithmic transformation was reported. * Mean value after adjusting for gender. ** Mean value after adjusting for gender, birthweight, survey site, nocturnal sleep time, middle- and high-level physical activity time, eating behavior score, balanced diet index score, parental BMI, and education level.

Table 7. Association of breastfeeding status with percentage of fat in children stratified by age

Variables	n	Percentage of body fat, %			
		Adjusted*	Difference (95% CI)	Adjusted**	Difference (95% CI)
Children aged 3 years					
Breastfeeding	632				
Never	72	18.22	Referent	18.44	Referent
Ever	560	18.07	-0.15 (-1.41, 1.11)	18.55	0.11 (-1.33, 1.55)
F value		0.05		0.02	
P value		0.817		0.882	
Breastfeeding duration (months)	613				
Never	72	18.22	Referent	18.44	Referent
< 4	68	18.54	0.32 (-1.86, 2.50)	19.40	0.96 (-1.56, 3.48)
4–	16	17.29	-0.93 (-4.40, 2.55)	17.49	-0.95 (-4.83, 2.94)
6–	172	17.99	-0.23 (-2.04, 1.58)	18.35	-0.09 (-2.20, 2.02)
12–	264	18.12	-0.10 (-1.82, 1.62)	18.39	-0.05 (-2.05, 1.95)
≥ 24	21	17.46	-0.76 (-3.95, 2.44)	19.13	0.69 (-3.06, 4.44)
F value		0.28		0.51	
P value		0.927		0.767	
Children aged 4 years					
Breastfeeding	692				
Never	68	18.87	Referent	19.10	Referent

Continued

Variables	n	Percentage of body fat, %			
		Adjusted*	Difference (95% CI)	Adjusted**	Difference (95% CI)
Ever	624	18.53	-0.35 (-1.69, 0.99)	18.63	-0.47 (-2.17, 1.23)
F value		0.26		0.29	
P value		0.611		0.590	
Breastfeeding duration (months)	656				
Never	68	18.87	Referent	19.23	Referent
< 4	78	19.17	0.30 (-1.94, 2.54)	19.49	0.26 (-2.50, 3.02)
4–	24	17.99	-0.89 (-4.11, 2.33)	17.79	-1.43 (-5.16, 2.29)
6–	195	18.65	-0.21 (-2.11, 1.69)	19.02	-0.21 (-2.63, 2.20)
12–	263	18.29	-0.58 (-2.41, 1.25)	18.47	-0.76 (-3.06, 1.54)
≥ 24	28	18.20	-0.67 (-3.72, 2.37)	18.17	-1.06 (-4.59, 2.46)
F value		0.47		0.60	
P value		0.801		0.702	
Children aged 5 years					
Breastfeeding	643				
Never	71	18.35	Referent	17.07	Referent
Ever	572	18.01	-0.34 (-1.82, 1.13)	18.50	1.43 (-0.50, 3.36)
F value		0.21		2.13	
P value		0.646		0.146	
Breastfeeding duration (months)	623				
Never	71	18.36	Referent	17.18	Referent
< 4	70	17.06	-1.30 (-3.82, 1.21)	18.51	1.34 (-1.85, 4.52)
4–	26	19.97	1.60 (-1.85, 5.06)	21.31	4.13 (0.13, 8.13)
6–	175	17.87	-0.49 (-2.61, 1.62)	18.07	0.89 (-1.89, 3.68)
12–	259	18.10	-0.27 (-2.28, 1.74)	18.38	1.20 (-1.39, 3.80)
≥ 24	22	18.53	0.17 (-3.51, 3.85)	19.68	2.50 (-1.81, 6.81)
F value		1.02		1.61	
P value		0.404		0.157	

Note. * Mean value after adjusting for gender. ** Mean value after adjusting for gender, birthweight, survey site, nocturnal sleep time, middle- and high-level physical activity time, eating behavior score, balanced diet index score, parental BMI, and education level.

exclusivity. However, there were no observed significant effects on BMI, waist or hip circumference, triceps thickness, or subscapular skinfold thickness at the age of 6.5 years^[32]. Weight gain results from linear growth and soft tissue gain. Linear growth appeared to be predominantly associated with childhood weight gain. This may partly explain why the significant results disappeared when WHZ/BAZ was used to represent the weight change separated from the change in height.

Association of Breastfeeding and Duration of Breastfeeding with Fat Mass Indicators

Three studies (two prospective studies^[16,33] and a retrospective study^[23]) showed no statistically significant difference in the fat mass of breastfed and formula-fed preschool children, which was measured using dual-energy X-ray absorptiometry (DXA), the gold standard for body composition measurement. Sobik et al.^[34] reported that there was no significant difference in fat mass index (FMI)

between breastfed (BF) and cow's milk-based formula-fed (MF) children at 36 and 48 months. However, by 60 and 72 months, BF children had significantly lower FMI (3.6 and 3.5 kg fat mass/m², respectively) than MF children (4.1 and 4.1 kg fat mass/m², respectively). In their study, 526 children [BF, MF, and Soy formula (SF) were 178, 179, and 169, respectively] were recruited at 1–2 months of age and followed up at 3, 6, 9, 12, 24, 36, 48, 60, and 72 months of age when body composition was measured using DXA. Although DXA and BIA were used to measure body composition in the study by Sobik et al. and in the current study, respectively, BIA and DXA reported high concordance for FM values^[35] and some studies reported results consistent with those of DXA^[23,33]. In addition, birth weight and physical growth of children are related to body composition; for example, the breastfeeding of preterm infants, compared with formula feeding, is associated with slower weight gain and lower fat mass^[36-37]. Sobik et al. excluded infants who were preterm (< 37 weeks), had birth weight < 2.7 kg or > 4.1 kg, and body weights < 5 kg at 3 months of age, which may have led to statistically significant results.

Similar to the results of the present study, some studies found no significant differences in fat mass indicators at 3 years^[22], 5–6 years^[23,38], 6–8 years of age^[39] among different breastfeeding durations. In contrast, Robinson et al. reported that children with longer duration of breastfeeding had lower fat mass at 4 years compared with never breastfed children (4.5 kg in children breastfed for 12 months or more and 5.0 kg in children never breastfed). Robinson et al. only adjusted for the timing of complementary feeding and some child and parental characteristics (such as gender, birth weight, maternal age, BMI, and education level), whereas we adjusted for those confounders and recent diet, eating behavior, physical activity, and night sleep time of preschool children. Therefore, the inconsistent association between these two studies may be partly explained by the confounders. Although different from the breastfeeding duration groups in our study, Hildebrand et al. recently reported that breastfeeding duration was inversely associated with the percentage body fat in children at ages 4–8 years^[40]. Their cross-sectional study included 823 children (16% were overweight and 13% obese), and they found that adjusted mean percentage body fat was 16.8, 14.5, and 13.4, respectively, for none, < 6, and ≥ 6 months of exclusive breastfeeding, although no statistically significant associations were observed between breastfeeding and obesity. As the present

study only included 9.6% overweight/obese children, our results do not refute the significant inverse association found in this study.

Association of Breastfeeding and Duration of Breastfeeding with Fat-free Mass Indicators

Compared to that of formula-fed children, the fat free mass of breastfed infants was higher for children aged 3 years (12.84 kg vs. 12.52 kg, $P = 0.015$) and lower for those aged 4 years (14.31 kg vs. 14.64 kg, $P = 0.048$); and the difference was eliminated for 5-year-old children (16.40 kg vs. 16.42 kg, $P = 0.914$) after adjusting for potential confounders. Due to the normal growth and development of preschool children and the introduction of confounders that affect infant feeding and child body composition, the effect of breastfeeding on fat-free mass has faded. Nancy et al.^[16] reported that the fat-free mass of formula-fed infants was higher than that of breastfed infants at 3 months of age, and the bone mineral content of formula-fed infants was higher than that of breastfed infants at 12 months; however, the difference was no longer statistically significant after 2 years of age. Furthermore, a systematic review and meta-analysis in 2012 showed that formula-fed infants had a higher fat-free mass at 3–4 months, 8–9 months, and 12 months of age than breastfed infants, but the difference was no longer significant after 12 months of age^[17]. In addition, according to the reference values of body composition for children aged 0–10 years in the United States, as reported by Fomon et al. in 1982^[41], and a review of body composition of children from the fetal stage to 5 years of age by Toro-Ramos et al. in 2015^[42], children aged 4–6 years experienced rapid increases in body fat and fat-free mass. Meanwhile, there were three age groups (3, 4, and 5 years) rather than a follow-up of the same population, although the basic characteristics were similar. Therefore, it could not be determined whether the differences originated from age or population. Future studies should explore the association of breastfeeding and fat-free mass in preschool children and its inconsistency with different ages.

Because linear growth appeared to be predominantly associated with childhood fat-free mass, we used the fat-free mass index to represent the fat-free mass change that was separated from the change in height, and found that there was no difference in the fat-free mass index between breastfed and non-breastfed infants. Sobik et al. reported findings consistent with ours^[34]. In addition,

consistent with our findings, some studies found no statistically significant difference in fat-free mass index in preschool children among different breastfeeding durations^[22,38-39].

The proportion of breastfeeding was 89.2% in this study. Li et al. summarized the data of 20 cities across China and found that the prevalence of breastfeeding at 0 or 1 month ranged from 82.09% in Shanghai (large city, Eastern China) to 99.5% in Akesu (a medium-sized city in Xinjiang Uygur Autonomous Region, West China) from 2007 to 2017^[43]. Globally, the prevalence of breastfeeding was approximately 97%, 95%, and 85% in lower-middle-, upper-middle-, and high-income countries, respectively, in 2010^[2]. Despite its established benefits, the prevalence of breastfeeding in some regions of China is much lower than that in other middle-income countries. Therefore, public health efforts should be made to raise awareness regarding the benefits of breastfeeding and its continuation in adherence to recommendations for optimal benefit.

Study Limitations

The present study explored the relationship between breastfeeding duration in infants and body composition of 3 to 5-year-old children in the Chinese population, which could provide scientific evidence for formulating infant and young child feeding guidelines to promote breastfeeding and early prevention of overweight and obesity in children. However, this study had several limitations. First, as this was a cross-sectional study, the relationship between breastfeeding in infants and body composition of preschool children may not be causal. In addition, as an observational study, unrecognized confounders may still exist, although we adjusted for some recognized confounders through stratified and multifactorial analyses. Finally, the study retrospectively collected data on breastfeeding duration in infants aged 3–5 years, which may lead to a recall bias.

CONCLUSION

Although breastfeeding has multiple health benefits, there may not be a clear association between breastfeeding duration and body fat mass. Future studies should explore the association between breastfeeding duration and fat-free mass in preschool children and its inconsistency with different ages. It is recommended that the government, health workers, and social forces join

efforts to foster a positive environment for breastfeeding and promote scientific breastfeeding in China for other health benefits.

AUTHORS' CONTRIBUTIONS

SHEN Li Ping and Dr. YANG Zhen Yu conceived the study. Dr. ZHANG Qian, PANG Xue Hong, WANG Yu Ying, Dr. WANG Jie, DUAN Yi Fan, CHEN Bo Wen, and XU Tao were involved in data collection. SHEN Li Ping and Dr. YANG Zhen Yu analyzed and interpreted the data. SHEN Li Ping wrote the first draft of this manuscript. Dr. YANG Zhen Yu revised the manuscript, provided feedback on the interpretation of the results, and supervised the entire study. Dr. ZHAO Wen Hua interpreted the data and critically reviewed the manuscript. All the authors have read and approved the final version of this manuscript.

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CONFLICTS OF INTEREST

The authors declare that they have no competing interests.

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