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Excessive Weight Gain during Full Breast-Feeding

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Key Words

Breast milk · Breast-feeding · Human milk composition · Protein · Growth · Obesity

Abstract

Background: Breast-feeding is considered to offer optimal nutrition for healthy infant growth and development. Observational studies have linked breast-feeding to reduced obesity. ***Case Observation:*** We observed an infant who was born macrosomic (4.56 kg) and showed excessive weight gain markedly exceeding the 97th percentile of weight during full breast-feeding. At the age of 4 months, the weight was greater than 11 kg. Clinical evaluation did not reveal any underlying pathology. After the introduction of complementary feeding and hence reduction of the breast milk intake, the excessive weight gain was attenuated and the slope of the percentile curve paralleled upper percentiles. Since this pattern suggested full breast-feeding as the driver of excessive weight gain, we analyzed the human milk composition at the infant age of 1 year and compared the results with published data on composition at this stage of lactation. ***Results:*** The milk contents of lactose, fat, fatty acids, polar lipids, carnitine species, and insulin were similar to the reference data. The adiponectin content was increased. The most remarkable alteration was a high milk protein content (mean 1.25 g/dl, reference 0.8 g/dl). ***Conclusions:*** A very high protein supply in infancy has been previously shown to increase plasma concentrations of the growth factors insulin and IGF-1, weight gain, and later obesity. We speculate that interindividual variations in human milk adiponectin and protein contents may contribute to modulation of the growth of fully breast-fed infants and in this case may have contributed to excessive weight gain during full breast-feeding. This hypothesis merits being tested in future cohort studies.

Background

Breast-feeding is recommended as the optimal source of nutrition for infants to support normal growth and development as well as long-term health [1]. Breast milk compositions vary with maternal diet, lifestyle, genetic determinants, and the duration of lactation [1–5]. However, little is known whether interindividual differences in human milk composition may induce relevant effects on infant growth and health outcomes. There are indications that variations in milk polyunsaturated fatty acid content induced by diet and genetic variations modulate cognitive development [6, 7] and the risk of asthma [8].

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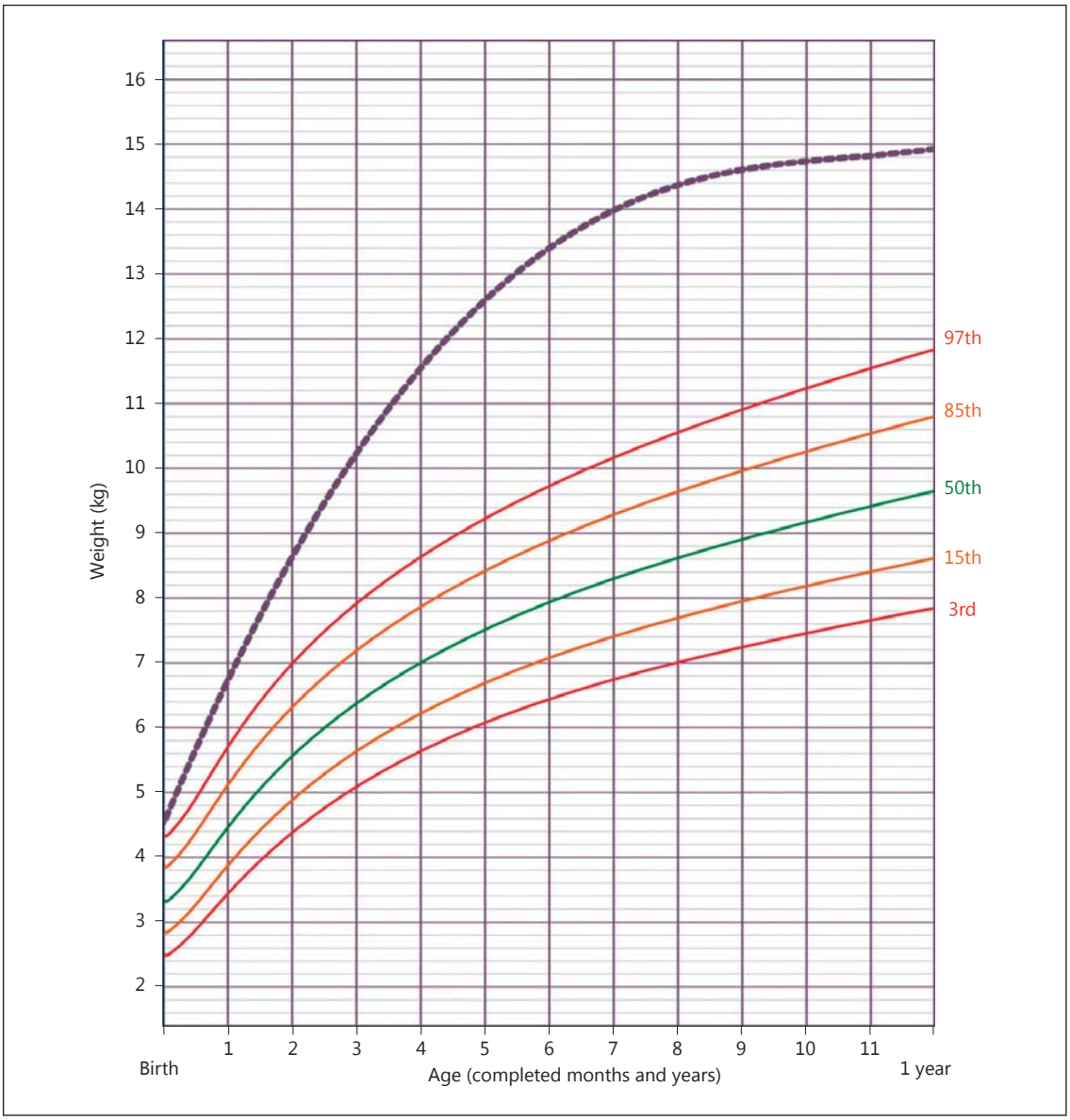

Fig. 1. Excessive gain of weight for age (dashed line) in the observed infant during the first 4 months of life during full breast-feeding, and attenuated weight gain during partial breast-feeding after the introduction of complementary feeding at the 5th month of life, plotted on the WHO weight-for-age reference [26].

Compared to formula feeding, breast-feeding is associated with a reduced risk of later obesity [9–11]. Traditionally, infant formulas have provided far higher protein contents than breast milk. A high protein supply in infancy in excess of the metabolic needs was proposed to induce increased plasma and tissue concentrations of insulin-releasing amino acids, increased secretion of the growth factors insulin and IGF-1, and thereby enhanced early weight gain and increased later obesity [11, 12]. This hypothesis was confirmed in a large randomized clinical trial demonstrating that a high protein supply to infants increases their plasma amino acid and growth factor concentrations [13], early weight gain [14], and obesity rates at school age [15].

We observed a fully breast-fed infant with an extremely high weight gain and therefore analyzed the maternal milk composition to explore potential factors that may have influenced the highly unusual weight development.

Table 1. Composition of fore- and hindmilk of the subject's mother at 1 year of lactation

Breast milk component	Foremilk	Hindmilk
Macronutrients		
Fat, g/dl	1.4	4.05
Carbohydrates, g/dl	6.7	6.1
Crude protein, g/dl	1.1	1.4
True protein, g/dl	0.9	1.1
Total solids, g/dl	9.45	12.05
Energy, kcal/dl	44	68.5
Adiponectin, ng/ml	33.06	36.99
Insulin, mU/l	15.1	18.2
Total carnitine, µmol/l	55.77	37.31
Free carnitine, µmol/l	39.63	22.44
Phosphatidylcholines, µmol/l	55.01	111.93
Sphingomyelins, µmol/l	54.67	124.48

Case Report

The male infant was born at 41^{+0} weeks of gestation as the second child of a 38-year-old, healthy mother after an uneventful pregnancy. The mother had a normal body weight and no gestational diabetes. The boy's older sister had been born with a weight of 3,200 g (–0.4 SD scores; SDS) but had become overweight during her breast-feeding period, whereas her weight had normalized again after cessation of breast-feeding. At the age of 5 years, her length was 106 cm (–0.41 SDS) and her weight was 17 kg (–0.43 SDS). The boy was born by cesarean section with a birth weight of 4.56 kg (+2.14 SDS) and a length of 54 cm (+1.53 SDS). The infant was fully breast-fed for 4 months. His length increased along the 97th percentile for age, whereas his body weight rapidly increased to 11.5 kg at 4 months (+4.28 SDS). After the introduction of complementary feeding, the slope of weight gain was reduced and thereafter paralleled the 97th percentile (fig. 1). At the age of 1 year, the child was referred to our department for further evaluation, with a weight of 15 kg (+3.12 SDS). There was a regular distribution of the excessive body fat, with circular fat folds, normal body proportions, and no signs of dysmorphism. No abnormalities of motor or neurological development were noted. Clinical and laboratory evaluations did not give any indication of an underlying genetic, syndromic, endocrine, or other abnormality. Rather, the course of the growth curve suggested an excessive weight gain velocity during the period of full breast-feeding, with normalization of the weight gain velocity after the introduction of complementary feeding and hence a reduced contribution of breast milk to the total dietary intake.

Analysis of Breast Milk Composition

The mother manually expressed samples of fore- and hindmilk at the boys' age of 1 year. We determined the macronutrient content in the fresh samples via mid-infrared transmission spectroscopy using a Miris Human Milk Analyzer (MIRIS AB, Uppsala, Sweden). The device is calibrated against ISO reference methods and provides the content of fat, carbohydrates, true protein and crude protein (including the nonprotein fraction), energy, and total solids.

Table 2. Fatty acid composition in human fore- and hindmilk of the subject's mother at 1 year of lactation, and reference data [18]

Fatty acid composition, %	Foremilk	Hindmilk	Reference values (mean ± SEM)
C10:0	1.39	1.39	1.14±0.026
C12:0	7.87	7.91	6.53±0.169
C14:0	8.82	9.11	9.27±0.220
C14:1	0.17	0.17	0.40±0.016
C15:0	0.27	0.28	0.45±0.016
C16:0	21.76	21.79	24.15±0.222
C17:0	0.29	0.29	0.40±0.008
C18:0	7.43	7.58	8.43±0.267
C20:0	0.20	0.22	0.66±0.014
C22:0	0.07	0.08	0.07±0.003
C24:0	0.05	0.06	0.05±0.002
C16:1n-7	1.50	1.44	2.32±0.073
C18:1n-9	31.93	31.61	30.21±0.261
C18:1n-7	1.48	1.46	1.45±0.043
C20:1n-9	0.37	0.37	0.22±0.005
C18:2 tt	0.07	0.07	0.33±0.018
C18:2n-6	13.17	13.13	9.28±0.345
C18:3n-6	0.15	0.15	0.13±0.01
C18:3n-3	0.96	0.91	0.79±0.031
C20:2n-6	0.23	0.20	0.06±0.001
C20:3n-6	0.25	0.24	0.19±0.006
C20:4n-6	0.45	0.43	0.34±0.006
C20:5n-3	0.05	0.04	0.06±0.003
C22:4n-6	0.09	0.08	0.07±0.003
C22:5n-3	0.13	0.12	0.17±0.004
C22:6n-3	0.21	0.20	0.18±0.005

Aliquots of fore- and hindmilk were frozen at –80°C and later thawed for analysis of the total lipid fatty acid composition by gas liquid chromatography [5] and total phosphatidylcholine and sphingomyelin and carnitine species via LC-MS/MS [16]. Milk adiponectin and insulin were measured by enzyme-linked immunosorbent assays (Human Adiponectin Elisa; BioVendor, Brno, Czech Republic, and Insulin Elisa; Mercodia, Uppsala, Sweden).

Results and Discussion

The results of the analysis of the mother's breast milk at 1 year postpartum are shown in tables 1 and 2. The breast milk composition changes with the duration of lactation. At 1 year after birth, there are lower milk contents of protein, calcium, and saturated very-long-chain fatty acids, whereas the contents of lactose and total fat

show little change compared to mature milk in the first months after birth [17]. Our results for milk contents of lactose, fat, and energy were within reported reference ranges [6, 17]. The observed increase in total fat content from foremilk (1.4 g/dl) to hindmilk (4.1 g/dl) was expected [6]. The milk fatty acid composition (table 2) did not show appreciable differences from reported reference data [18]. The milk phosphoglyceride and sphingomyelin contents (table 1) were within the expected range of concentrations. Milk carnitine was higher in foremilk (56 μmol/l) than in hindmilk (37 μmol/l), with a calculated mean carnitine concentration in the dimension of values reported at 4 months of lactation (62 μmol/l) [19].

The mean milk insulin concentration of 16.7 mU/l was similar to reported milk insulin levels of about 15.64 ± 1.03 mU/l [20]. The mean adiponectin concentration of 35.0 ng/ml was slightly higher than previously reported milk concentrations at 1 year of lactation of 25.7 ± 1.4 ng/ml [21]. Adiponectin receptor 1 was detected in rodent small intestine, which might facilitate the absorption of milk adiponectin and thus have the appetite-enhancing effect of high milk adiponectin levels [22]. In fact, high levels of breast milk adiponectin have been associated with an increased risk of child overweight at 2 years of age [23].

The high mean protein content of 1.25 g/dl and the high protein concentration of 1.4 g/dl in hindmilk are remarkable. The milk protein content was higher in colostrum and early mature milk and decreased significantly with increasing duration of lactation [6]. The milk of mothers of infants born at term usually has a protein concentration of 1.4 g/dl at 1 month after birth and 0.8 g/dl at 1 year postpartum [17]. Thus, the measured protein content in the milk of our subject's mother was 1.56-fold (foremilk) to 1.75-fold (hindmilk) higher than expected.

While breast-feeding generally reduces the risk of a high weight gain and the development of obesity [9–11], in the infant reported here full breast-feeding induced excessive weight gain and marked obesity which was attenuated when the breast milk intake was reduced after the introduction of complementary feeding. While different factors such as feeding habits and the milk volume provided may have contributed to this highly unusual growth pattern, we consider it possible that an abnormal milk composition may have contributed to the child's obesity. Specifically, we observed a higher-than-usual milk adiponectin content, which was previously associated with increased later obesity in an observational study [23], and a high breast milk protein content concentration, which in the case of a high formula protein content has been shown to induce a high early weight gain as well as increased later obesity [14, 15]. While the observation of a single case cannot prove causality, this observation leads us to hypothesize that interindividual variations in human milk composition may modulate child growth patterns and the obesity risk. We intend to investigate this hypothesis further by analyzing the human milk composition in mother-infant pairs followed in the EarlyNutrition research project [24, 25].

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Disclosure Statement

The authors declare no conflicts of interest.

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