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ORIGINAL COMMUNICATION

Maternal body mass index, duration of exclusive breastfeeding and children's developmental status at the age of 6 years

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Objective: To investigate whether the duration of exclusive breastfeeding and maternal body mass index (BMI) are associated with children's developmental status at the time of beginning elementary school.
Design and subjects: The subjects in the sample came from a longitudinal study on infant nutrition in Iceland. Food records were made once a month from birth to the age of 12 months, from which duration of exclusive breastfeeding could be determined. Mothers filled in The Icelandic developmental inventory for evaluation of motor and verbal development close to their children's sixth birthday ($n=85$). Maternal self-reported weight and height was recorded. Information on socioeconomic factors was gathered by a questionnaire.
Results: Duration of exclusive breastfeeding, in months, was positively related to children's motor component ($B=0.5\pm0.5$, $P=0.054$) and to the total developmental index ($B=1.0\pm0.5$, $P=0.044$) at 6 y, adjusting for gender and socioeconomic factors (maternal and paternal education, and family income). Children's learning score was negatively related to maternal BMI ($B=-0.5\pm0.2$, $P=0.047$). An inverse association also appeared between maternal BMI and two out of the three developmental composite scores, that is, verbal component and the total developmental index ($B=-0.6\pm0.3$, $P=0.049$) and ($B=-0.4\pm0.2$, $P=0.057$), respectively. In multiple regression the developmental indexes were most strongly independently associated with maternal BMI (negatively) and infants' birth weight (positively).
Conclusion: Maternal BMI and duration of breastfeeding were associated with verbal and motor development of 6-y-old children, independent of socioeconomic factors. Birth weight was also an independent determinant for developmental scores.
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Introduction

Many studies have examined whether suboptimal nutrition in early life, at a critical phase of brain development, could affect later cognitive function in children (Lucas *et al*, 1998; Anderson *et al*, 1999). Most of these studies have compared breast-fed children to those exclusively formula-fed, or assessed the relationship between total duration of breastfeeding and later cognitive functioning (Anderson *et al*, 1999). Reports are lacking on the association between duration of exclusive breastfeeding and later developmental status of children.

Duration of breastfeeding depends on several factors, some of them socioeconomic (Lande *et al*, 2003). Studies suggest that overweight mothers are less likely than normal weight mothers to breast-feed their children (Rutishauser & Carlin, 1992; Li *et al*, 2002), and maternal body mass index (BMI) is negatively associated with total duration of breastfeeding (Thorsdottir *et al*, 2003b). A recent study indicated that

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prepregnantly obese women are at risk of having children with diminished intellectual ability at the age they start school (Neggers *et al*, 2003). More knowledge is needed about the relationship between mothers' current BMI and children's developmental status at school start.

The prevalence of overweight and obesity is increasing around the world (Peeters *et al*, 2003), which might eventually result in a decreased frequency of breastfeeding. The negative impact of obesity on psychosocial functioning is also considerable and disturbances are connected with poor mental health (Karlsson *et al*, 2003) and low socioeconomic status.

The aim of this study was to investigate whether the duration of exclusive breastfeeding as well as maternal BMI are associated with children's developmental status at school start.

Subjects and methods

Subjects

The subjects in the sample came from a longitudinal study on infant nutrition in Iceland (Atladottir & Thorsdottir, 2000). A random sample was taken over a period of 20 months of normal, healthy newborns at four different maternity wards around Iceland, distributed by place and date of birth according to Statistics Iceland. The criteria for participation were singleton birth, a gestation period of 37–41 weeks, birth weight between the 10th and 90th percentile, no birth defects or inborn long-term diseases, Icelandic parents, mothers receiving early and regular antenatal care and complete information on duration of exclusive breastfeeding in infancy ($n = 109$). The subjects were followed until their sixth birthday when participating mothers completed the Icelandic developmental inventory. Complete data sets were available for 85 children (43 boys and 42 girls), 78% of the original cohort, and for 71 mothers (65%).

The Local Ethical Committee at the Landspitali-University Hospital in Iceland and the Icelandic Data Protection Commission approved the study.

The Icelandic developmental inventory

The Icelandic developmental inventory evaluates motor and verbal development of children between the ages of 3 and 6 by collecting information from their mothers. The mothers check a list of 208 standardized questions about their child's current verbal and motor abilities. The evaluation takes about 45 min and the method has proven to yield both reliable and valid informaion, directly comparable to traditional developmental measures (Gudmundsson & Gretarsson, 1993, 1994). The inventory yields scores on six subtests, which form two composite components, verbal and motor, and a general developmental index. The subtests are Gross Motor, Fine motor, Self Help, Comprehension, Expression, and Learning (see Table 1). The first three subtests comprise a motor component, and the latter three a verbal component.

Table 1 The Icelandic developmental inventory

Motor component	
Gross motor	Locomotor ability and large muscle movements
Fine motor	Delicate use of hands and fingers
Self-help	Ability to take care of himself/herself
Verbal component	
Comprehension	Understanding of spoken language
Expression	Ability to speak with proper syntax and grammar
Learning	Common skills and tasks

The development and standardization of the interventory involved measures from more than 2500 Icelandic mothers (Gudmundsson & Gretarsson, 1993, 1994). The successful development of the inventory shows that—given proper methods of gathering information—mothers themselves can assess their children's development with psychometric accuracy.

Infant feeding

Food records for the infants were made once a month from birth to the age of 12 months. The food records, which were completed by the infants' parents or caretakers close to the infants' monthly 'birthday', covered at least 24 h where all food ingested by the infant was recorded (Atladottir & Thorsdottir, 2000; Gunnarsdottir & Thorsdottir, 2003; Thorsdottir *et al*, 2003a, b). From these records, duration of exclusive breastfeeding (months) could be determined.

Maternal anthropometry and socioeconomic status

Maternal self-reported weight and height were recorded around her child's sixth birthday and BMI calculated. Overweight was defined as having BMI $\geq 25\ kg/m^2$. Information on socioeconomic factors, that is, parents' education and age as well as family income, was gathered by a questionnaire. Education was grouped into three categories, that is, secondary school degree, college or gymnasium degree and universiy degree. Family income was collected by questions grouping the income into five categories.

Calculation and statistical analysis

Statistical analyses were performed, using SPSS for Windows version 11.0. (SPSS Inc., Chicago, IL, USA). Of the six subtests, learning was normally distributed in the sample, but other single subtests were not. The three composite scores, Verbal, Motor and the Total Development index, were normally distributed. Mean and standard deviations were used to describe the data. Spearman's correlation was used to assess the relationship between maternal BMI as well as duration of exclusive breastfeeding and developmental domains that were not normally distributed. Linear regression was used to assess relationships between normally distributed variables, and multiple regression analysis made

to rule out the parameters predicting developmental status at the age of 6 y, and to allow for potential confounding factors, such as mothers' and fathers' education and age as well as family income. The sample size was calculated to give at least a power of 80 and $P<0.05$. Significance level was set as $P<0.05$.

Results

The mean maternal age and BMI as well as infants' birth weight and months of exclusive breastfeeding are shown in Table 2. The range of exclusive breastfeeding was 0–6 months. Almost all infants were initially breast-fed, that is, 98%. Maternal BMI ranged from 18.8 to 41.5 kg/m^2, and 31 out of the 71 mothers participating, were defined as being overweight or obese. Mean developmental scores can also be seen in Table 2. Only two children were below the normal range in any of the developmental factors assessed and most of them fell within the normal range.

Table 3 shows the mean duration of exclusive breastfeeding, and maternal BMI in each educational group. Women with the least education (secondary school only) exclusively breast-fed their children 1.1 months shorter than did mothers who had a university degree ($P=0.037$). Older parents tended to be more educated and have higher family income than younger ones. Maternal and paternal age correlated positively with children's learning score ($r=0.268$, $P=0.028$ and $r=0.271$, $P=0.027$, respectively), but not to the other developmental factors. More educated fathers tended to have children with higher learning scores and leaner wives, but the difference between education groups was not significant.

Duration of exclusive breastfeeding, in months, was positively related to children's motor component ($B=0.5\pm0.5$, $P=0.054$, adj. $R^2=0.063$) and to the total developmental index ($B=1.0\pm0.5$, $P=0.044$, adj. $R^2=0.032$), adjusting for gender and socioeconomic factors (maternal and paternal education, and family income).

An inverse association was seen between maternal BMI and their children's developmental scores at the age of 6 y. The regression coefficients can be seen in Table 4, both gender adjusted and adjusted for gender, socioeconomic factors (maternal and paternal education and family income).

Differences were seen in the learning subtest, verbal component and the total developmental index between children of normal weight mothers and those of who were overweight. Mean learning subtest scores for the 6-y-old children were 62 ± 7 and 57 ± 8 for those who had a normal- and overweight mother, respectively ($P=0.033$). Corresponding figures for the verbal component and the total developmental index were 112 ± 7 *vs* 107 ± 2, $P=0.024$ and 108 ± 5 *vs* 105 ± 7, $P=0.053$, respectively.

The final regression models can be seen in Table 5, where backwards multiple regression was used to see which variables were strongest associated with children's development. The factors affecting the developmental scores were

Table 2 Mean developmental scores and description of the study population

	N	*Mean*±*s.d.*
Developmental scores		
Gross motor	85	52.7±4.4
Fine motor	85	48.8±2.7
Self-help	85	52.7±4.2
Comprehension	85	52.0±3.5
Expression	85	51.5±3.2
Learning	85	60.0±7.6
Motor, combined	85	103.2±6.5
Verbal, combined	85	110.2±9.1
Total development index	85	106.8±6.5
Birth weight (g)	85	3845±454
Exclusive breastfeeding (months)	85	3.1±1.8
Maternal weight (kg)	71	71.6±13.3
Maternal height (cm)	71	167.3±5.2
Maternal BMI (kg/m^2)	71	25.5±4.4
Maternal age (y)	71	30.6±5.4

Table 3 Duration of exclusive breastfeeding, maternal BMI and the prevalence of overweight or obesity according to fathers' and mothers' education

	Duration of exclusive breastfeeding (months)	*Maternal BMI (kg/m^2)*
Fathers' education		
Secondary school	2.9±2.0	25.1±4.1
College/gymnasium	3.2±1.7	26.0±4.5
University	3.1±1.5	23.5±3.0
Mothers' education		
Secondary school	2.3±1.6	26.3±4.8
College/gymnasium	3.4±1.8	24.7±4.1
University	3.4±1.6	24.8±3.8

Values are mean±s.d.

Table 4 Multiple regression analysis of the association between maternal current body mass index and children's development scores at the age of 6 y

	B±*s.e.*	P	*adj.* R^2
Learning, subtest			
Adjusted for gender	−0.5±0.2	0.017	0.108
Adjusted for gender and social factors[a]	−0.5±0.2	0.047	0.091
Verbal component			
Adjusted for gender	−0.6±0.2	0.022	0.064
Adjusted for gender and social factors[a]	−0.6±0.3	0.049	0.054
Total developmental index			
Adjusted for gender	−0.3±0.2	0.052	0.038
Adjusted for gender and social factors[a]	−0.4±0.2	0.057	0.026

[a]Adjusted for maternal and paternal education and family income.

Table 5 Multiple regression models showing the association between independent variables[a] and developmental scores

Dependent variables																
Learning				*Motor component*				*Verbal component*				*Total developmental index*				
Model	*B*	*s.d*	P	*Model*	*B*	*s.d*	P	*Model*	*B*	*s.d*	P	*Model*	*B*	*s.d*	P	
1				1				1				1				
M BMI	−0.5	0.3	0.062	M BMI	−0.1	0.2	0.689	M BMI	−0.5	0.3	0.078	M BMI	−0.3	0.2	0.122	
E BF	−0.4	0.8	0.604	E BF	0.9	0.6	0.135	E BF	−0.2	0.9	0.860	E BF	0.4	0.6	0.534	
BW	5.1	3.0	0.100	BW	−1.2	2.4	0.623	BW	6.3	3.4	0.071	BW	2.5	2.4	0.300	
M Edu	0.2	1.4	0.865	M Edu	0.0	1.1	0.976	M Edu	0.7	1.6	0.655	M Edu	0.4	1.1	0.754	
F Edu	2.2	1.9	0.241	F Edu	−4.2	1.5	0.007	F Edu	2.1	2.1	0.329	F Edu	−1.0	1.4	0.510	
Income	−0.2	1.8	0.906	Income	1.8	1.4	0.209	Income	0.1	2.0	0.960	Income	0.9	1.4	0.512	
Sex	−1.8	2.3	0.424	Sex	−0.9	1.8	0.633	Sex	−1.3	2.6	0.624	Sex	−1.3	1.8	0.480	
2				2				2				2				
M BMI	−0.5	0.3	0.059	M BMI	−0.1	0.2	0.685	M BMI	−0.5	0.3	0.071	M BMI	−0.3	0.2	0.119	
E BF	−0.4	0.8	0.597	E BF	0.9	0.6	0.115	E BF	−0.2	0.9	0.860	E BF	0.4	0.6	0.459	
BW	5.1	3.0	0.097	BW	−1.2	2.3	0.613	BW	6.3	3.3	0.066	BW	2.4	2.3	0.310	
M Edu	0.2	1.4	0.867	F Edu	−4.1	1.4	0.004	M Edu	0.7	1.6	0.650	F Edu	−0.8	1.4	0.552	
F Edu	2.1	1.7	0.221	Income	1.8	1.4	0.203	F Edu	2.1	1.9	0.282	Income	0.9	1.4	0.501	
Sex	−1.9	2.2	0.413	Sex	−0.9	1.8	0.630	Sex	−1.3	2.5	0.621	Sex	−1.2	1.8	0.481	
3				3				3				3				
M BMI	−0.5	0.2	0.056	E BF	1.0	0.6	0.088	M BMI	−0.5	0.3	0.068	M BMI	−0.3	0.2	0.126	
E BF	−0.4	0.7	0.611	BW	−1.3	2.3	0.568	BW	6.0	2.9	0.045	E BF	0.4	0.6	0.467	
BW	5.0	2.9	0.095	F Edu	−4.1	1.3	0.004	M Edu	0.7	1.5	0.670	BW	2.8	2.2	0.203	
F Edu	2.2	1.6	0.164	Income	1.9	1.4	0.176	F Edu	2.1	1.9	0.272	Income	0.6	1.3	0.629	
Sex	−1.8	2.2	0.410	Sex	−0.9	1.7	0.597	Sex	−1.3	2.5	0.590	Sex	−1.1	1.7	0.526	
4				4				4				4				
M BMI	−0.5	0.2	0.062	E BF	−0.8	2.1	0.690	M BMI	−0.5	0.3	0.062	M BMI	−0.3	0.2	0.098	
BW	4.3	2.6	0.102	BW	0.9	0.5	0.097	BW	6.0	2.9	0.043	E BF	0.4	0.6	0.446	
F Edu	2.2	1.6	0.167	F Edu	−4.0	1.3	0.004	F Edu	2.4	1.8	0.176	BW	2.8	2.2	0.204	
Sex	−2.1	2.2	0.347	Income	1.8	1.3	0.182	Sex	−1.2	2.4	0.610	Sex	−1.1	1.7	0.528	
5				5				5				5				
M BMI	−0.5	0.2	0.055	E BF	0.8	0.5	0.098	M BMI	−0.5	0.3	0.056	M BMI	−0.3	0.2	0.082	
BW	5.2	2.4	0.037	F Edu	−3.8	1.2	0.003	BW	6.6	2.7	0.019	E BF	0.4	0.6	0.507	
F Edu	2.4	1.6	0.134	Income	1.8	1.3	0.184	F Edu	2.5	1.7	0.152	BW	3.3	2.0	0.102	
6				6				6				6				
M BMI	−0.5	0.2	0.032	E BF	0.9	0.5	0.072	M BMI	−0.6	0.3	0.033	M BMI	−0.4	0.2	0.054	
BW	4.1	2.3	0.085	F Edu	−3.2	1.1	0.008	BW	5.4	2.6	0.043	BW	3.9	1.8	0.035	

[a]Backwards multiple regression including the independent variables maternal BMI, duration of exclusive breastfeeding, birthweight parents' education and family income.
M BMI: Maternal body mass index (kg/m^2), E BF: Exclusive breastfeeding (months), BW: birth weight (kg), M Edu: Maternal education, F Edu: Fathers education, Income: Family income, Sex: 1 = boy, 2 = girl.

mothers' BMI (negatively) and infants' birth weight (positively).

Discussion

Current maternal BMI was negatively related to children's learning and verbal development at the age of 6 y, even when adjusting for socioeconomic factors. To our best knowledge, this association has not been discussed before. Longer duration of exclusive breastfeeding was associated with better motor development.

A meta-analysis from 1999 showed that children who are breast-fed score higher on tests of cognitive development than do children who are formula-fed (Anderson *et al*, 1999). This meta-analysis included mainly studies in which breast-fed children were compared to those who were exclusively formula-fed. Increasing benefit with total duration of breastfeeding has been shown (Angelsen *et al*, 2001). However, studies showing the benefits of exclusive breastfeeding have been lacking.

In the present study, longer duration of exclusive breastfeeding was associated with higher motor development score, even after adjustment for confounding factors. A Danish study of 1656 children found that motor milestones were achieved at an earlier age in breast-fed than in formula-fed infants (Vestergaard *et al*, 1999), and in a recent study by Angelsen *et al* (2001) a small positive effect of breastfeeding on motor development cannot be excluded. However, some

previous studies did not find an association between duration of breastfeeding and motor development (Florey *et al*, 1995).

Certain constituents of breast milk, for example, docosahexaenoic acid, are known to be associated with infant mental development (Uauy & De Andraca, 1995; Koletzko & Rodriguez-Palmero, 1999). Docosahexaenoic acid in breast milk is associated with maternal intake of the fatty acid (Helland *et al*, 1998) and maternal supplementation may be favorable for later mental development of children (Helland *et al*, 2003). However, there is little evidence that they affect motor development. Another possibility explaining the mechanism by which breastfeeding is associated with children's development is that the intimacy of breastfeeding might be important for the infant development (Lucas & Morley, 1992). The mechanism for the positive effect of long duration of exclusive breastfeeding seen in the present study on children's motor development, and the positive effect of breastfeeding when compared with formula-fed infants (Vestergaard *et al*, 1999), must be studied further.

The prevalence of obesity is increasing rapidly worldwide (World Health Organization, 1998), and Iceland is no exception (Thorgeirsdottir *et al*, 2001). The relationship between maternal BMI and children's learning, as well as verbal development score, was significant even after adjusting for maternal and paternal education, as well as the family income. Explanations other than education, age and family income must therefore be considered for the observed association.

The inverse relationship between maternal BMI and children's verbal development could possibly be mediated through effects of maternal depression. Studies support the possibility of depression promoting obesity and *vice versa* as association has been seen between the factors in several studies (Wadden *et al*, 1988, 1997; Istvan *et al*, 1992; Sullivan *et al*, 1993; Faith *et al*, 2002), while older cross-sectional studies do not support this relation (Crisp & McGuinness, 1976; Stewart & Brook, 1983). Lower levels of cognitive stimulation, because of depression or low self-esteem among heavier mothers cannot be excluded. An other possibility is that due to lower self-esteem and depression, heavier mothers could possibly underestimate their children's cognitive function. The Icelandic individual developmental test is based on questions answered by the mothers.

It is unlikely that properties of nonparticipants could introduce bias in the results of the present study as no significant difference was seen in birth weight or duration of exclusive breastfeeding between the participating and nonparticipating children. A limitation to the present study could be considered that maternal BMI was self-reported, but as the children's health, not the mothers', was the main subject of the study, this was not considered as a serious risk for bias.

A recent study indicated that women with high prepregnancy BMI are at risk of having children with diminished intellectual ability at an age close to starting school (Neggers *et al*, 2003). It is likely that the heavier mothers in the present study were also heavy prepregnantly (Thorsdottir & Birgisdottir, 1998; Sichieri *et al*, 2003), and therefore fetal influences of high maternal weight cannot be excluded. Several studies have indicated that malnutrition during pregnancy can negatively affect both the birth weight and cognitive function of infants, and this effect may still be present even in adulthood (Feingold, 1994; Camp *et al*, 1998; Ramsay & Reynolds, 2000). The negative effect of low birth weight on cognitive function has been reported at ages 11, 15 and 26 y of age (Richards *et al*, 2001). The present study observed a positive association between children's birth weight and development at 6 y of age and therefore support the former studies.

Although maternal BMI predicted several development factors in 6-y-old children, in the models used in the present study, social influences are also clearly involved. However, our results indicate that factors other than education, age and income associated with maternal BMI are involved in determining children's developmental status. According to the results of the present study, less educated women are less likely to exclusively breast-feed their children. Heavier mothers are also less likely to have a long total duration of breastfeeding, but the duration of exclusive breastfeeding is not related to the maternal BMI (Thorsdottir *et al*, 2003b). However, a combination of these two nutritional factors must be considered likely to be involved in determining the development status of children at school start. Birth weight, indicating fetal development, is also an independent factor associated with cognitive function among the 6-y-olds.

In 2001, the World Health Assembly (WHA) suggested that the recommendations for exclusive breastfeeding should be increased from 4 to 6 months (World Health Assembly, 2001). Although we did not have the opportunity to compare the motor development scores between children exclusively breast-fed for 6 months to those exclusively breast-fed for a shorter period, our results suggest long-term benefits of longer duration of exclusive breastfeeding with regard to motor development. The results are therefore of great value to individuals working in the field of pediatric nutrition and childcare.

Both maternal BMI and duration of exclusive breastfeeding are independent of socioeconomic factors predicting verbal and motor development of 6-y-old children. Promotion of healthy lifestyles prior to and in pregnancy to prevent overweight and obesity among women of child-bearing age and promote optimal nutrition, should be of priority. Attention should also be drawn to the means of increasing the duration of exclusive breastfeeding.

References

Anderson JW, Johnstone BM & Remley DT (1999): Breast-feeding and cognitive development: a meta-analysis. *Am. J. Clin. Nutr.* **70**, 525–535.

Angelsen NK, Vik T, Jacobsen G & Bakketeig LS (2001): Breast feeding and cognitive development at age 1 and 5 years. *Arch. Dis. Child.* **85**, 183–188.

Atladottir H & Thorsdottir I (2000): Energy intake and growth of infants in Iceland—a population with high frequency of breast-feeding and high birthweight. *Eur. J. Clin. Nutr.* **54**, 695–701.

Camp BW, Broman SH, Nichols PL & Leff M (1998): Maternal and neonatal risk factors for mental retardation: defining the 'at-risk' child. *Early Hum. Dev.* **50**, 159–173.

Crisp AH & McGuinness B (1976): Jolly fat: relation between obesity and psychoneurosis in general population. *BMJ* **1**, 7–9.

Faith MS, Matz PE & Jorge MA (2002): Obesity–depression associations in the population. *J. Psychosom. Res.* **53**, 935–942.

Feingold C (1994): Correlates of cognitive development in lowbirthweigth infants from low income families. *J. Pediatr. Nurs.* **9**, 91–99.

Florey CD, Leech AM & Blackhall A (1995): Infant feeding and mental and motor development at 18 months of age in first born singletons. *Int. J. Epidemiol.* **24** (Suppl 1), S21–S26.

Gudmundsson E & Gretarsson SJ (1993): The reliability and validity of the Icelandic Parent Development Inventory for children from 36 months to 72 months. *Educ. Psychol. Meas.* **53**, 571–584.

Gudmundsson E & Gretarsson SJ (1994): Adult's estimates of preschool children's verbal and motor abilities compared with those children's scores on an individual developmental test. *Early Dev. Parent.* **3**, 161–170.

Gunnarsdottir I & Thorsdottir I (2003): Relationship between growth and feeding in infancy and body mass index at the age of 6 years. *Int. J. Obes. Relat. Metab. Disord.* **27**, 1523–1527.

Helland IB, Saarem K, Saugstad OD & Drevon CA (1998): Fatty acid composition in maternal milk and plasma during supplementation with cod liver oil. *Eur. J. Clin. Nutr.* **52**, 839–845.

Helland IB, Smith L, Saarem K, Saugstad OD & Drevon CA (2003): Maternal supplementation with very-long-chain n-3 fatty acids during pregnancy and lactation augments children's IQ at 4 years of age. *Pediatrics* **111**, e39–e44.

Istvan J, Zavela K & Weidner G (1992): Body weight and psychological distress in NHANES I. *Int. J. Obes. Relat. Metab. Disord.* **16**, 999–1003.

Karlsson J, Taft C, Sjostrom L, Torgerson JS & Sullivan M (2003): Psychosocial functioning in the obese before and after weight reduction: construct validity and responsiveness of the obesity-related problems scale. *Int. J. Obes. Relat. Metab. Disord.* **27**, 617–630.

Koletzko B & Rodriguez-Palmero M (1999): Ployunsaturated fatty acids in human milk and their role in early infant development. *J. Mamm. Gland Bio. Neoplasia* **4**, 269–284.

Lande B, Andersen LF, Baerug A, Trygg KU, Lund-Larsen K, Veierod MB & Bjorneboe GE (2003): Infant feeding practices and associated factors in the first six months of life: the Norwegian infant nutrition survey. *Acta Paediatr.* **92**, 152–161.

Li R, Ogden C, Ballew C, Gillespie C & Grummer-Strawn L (2002): Prevalence of exclusive breastfeeding among US infants: the Third National Health and Nutrition Examination Survey (Phase II, 1991–1994). *Am. J. Public Health* **92**, 1107–1110.

Lucas A & Morley R (1992): Breast milk and subsequent intelligence quotient in children born preterm. *Lancet* **339**, 261–264.

Lucas A, Morley R & Cole TJ (1998): Randomized trial of early diet in pre-term babies and later intelligence quotient. *BMJ* **317**, 1481–1487.

Neggers YH, Goldenberg RL, Ramey SL & Cliver SP (2003): Maternal prepregnancy body mass index and psychomotor development in children. *Acta Obstet. Gynecol. Scand.* **82**, 235–240.

Peeters A, Barendregt JJ, Willekens F, Mackenbach JP, Mamun AA & Bonneux L (2003): Obesity in adulthood and its consequences for life expectancy: a life-table analysis. *Ann. Intern. Med.* **138**, 24–32.

Ramsay MC & Reynolds CR (2000): Does smoking by pregnant women influence IQ, birth weigth, and developmental disabilities in their infants? A methodological review and multivariate analysis. *Neuropsychol. Rev.* **10**, 1–40.

Richards M, Hardy R, Kuh D & Wadsworth MEJ (2001): Birth weight and cognitive functions in the British 1946 birth cohort: longitudinal population based study. *BMJ* **322**, 199–203.

Rutishauser IH & Carlin JB (1992): Body mass index and duration of breast-feeding: a survival analysis during the first six months of life. *J. Epidemiol. Community Health.* **46**, 559–565.

Sichieri R, Field AE, Rich-Edwards J & Willet WC (2003): Prospective assessment of exclusive breastfeeding in relation to weight change in women. *Int. J. Obes. Relat. Metab. Disord.* **27**, 815–820.

Stewart AL & Brook RH (1983): Effects of being overweight. *Am. J. Public Health* **73**, 171–178.

Sullivan M, Karlsson J, Sjostrom L, Backman L, Bengtsson C, Bouchard C, Dahlgren S, Jonsson E, Larsson B, Lindstedt S, Näslund I, Olbe L & Wedel H (1993): Swedish obese subjects (SOS)—an intervention study of obesity. Baseline evaluation of health and psychosocial functioning in the first 1743 subjects examined. *Int. J. Obes. Relat. Metab. Disord.* **17**, 503–512.

Thorgeirsdottir H, Steingrimsdottir L, Olafsson O & Gudnason V (2001): Trends in overweight and obesity in 45–64 year old men and women in Reykjavik 1975–1994. *Icelandic Med. J.* **87**, 699–704 (in Icelandic).

Thorsdottir I & Birgisdottir BE (1998): Different weight gain in women of normal weight before pregnancy: postpartum weight and birth weight. *Obstet. Gynecol.* **92**, 377–383.

Thorsdottir I, Gunnarsson BS, Atladottir H, Palsson G & Michaelsen KF (2003a): Iron status at 12 months of age—effects of body size, growth and diet in a population with high birth weight. *Eur. J. Clin. Nutr.* **57**, 505–513.

Thorsdottir I, Gunnarsdottir I & Palsson GI (2003b): Association of birth weight and breast-feeding with coronary heart disease risk factors at the age of 6 years. *Nutr. Metab. Cardiovasc. Dis.* **13**, 267–272.

Uauy R & De Andraca I (1995): Human milk and breast feeding for optimal mental development. *J. Nutr.* **125** (Suppl 8), S2278–S2280.

Vestergaard M, Obel C, Henriksen TB, Sorensen HT, Skajaa E & Ostergaard J (1999): Duration of breastfeeding and developmental milestones during the latter half of infancy. *Acta Paediatr.* **88**, 1327–1332.

Wadden TA, Stunkard AJ & Liebschutz J (1988): Three-year follow-up of the treatment of obesity by very low calorie diet, behavior therapy, and their combination. *J. Consult. Clin. Psychol.* **56**, 925–928.

Wadden TA, Vogt RA, Andersen RE, Bartlett SJ, Foster GD, Kuehnel RH, Wilk J, Weinstock R, Buckenmeyer P, Berkowitz RI & Steen SN (1997): Exercise in the treatment of obesity: effects of four interventions onbody composition, resting energy expenditure, appetite, and mood. *J. Consult. Clin. Psychol.* **65**, 269–277.

World Health Assembly (2001): *Infant and Young Child Nutrition* Resolution No. WHA 54.2. Geneva: World Health Organization.

World Health Organization (1998): *Obesity: Preventing and Managing the Global Epidemic*. Report of a WHO consultation, Geneva, 3–5 June 1997. WHO/NUT/98.1. Geneva: WHO.