Dietary fat intakes in infants and primary school children in Germany[1–4]

Berthold Koletzko, Katharina Dokoupil, Susanne Reitmayr, Barbara Weimert-Harendza, and Erich Keller

ABSTRACT We report dietary fat intake data in groups of infants and children in Germany. A group of 148 healthy infants was followed prospectively from birth through the first year of life. After birth, 78.9% of infants were breast-fed; 50% were breast-fed at 3 mo and 9.8% were breast-fed at 12 mo. Infant formula was given to 22% of infants after birth, 53% at 3 mo, and 58% at 12 mo. Complementary foods were consumed by 16% of infants at 3 mo, 97% at 6 mo, and 98–100% at 7–12 mo. In non-breast-fed infants, mean dietary fat intakes were 44.8%, 42.9%, 37.4%, and 35.7% of energy intake at the ages of 1, 4, 6, and 12 mo, respectively. Calculated energy and nutrient intakes were within recommended ranges and weight gain was normal. Therefore, we see no compelling reason to actively modify total fat intakes at this age. In 158 primary school children aged 6–11 y, 7-d checklist protocols showed 41% of energy intake as fat with ≈50% as saturated fat. Because German children of this age are experiencing increasing rates of obesity and high serum cholesterol concentrations, a stepwise reduction of total fat and saturated fat intakes in primary school children appears desirable to improve long-term health. *Am J Clin Nutr* 2000;72(suppl):1392S–8S.

KEY WORDS Diet, fat intake, lipids, saturated fat, coronary heart disease, infants, children, Germany

INTRODUCTION

The desirable ranges of the amounts and the composition of dietary lipid intake during childhood are the subject of ongoing discussions, and recent recommendations on these questions vary (1–7) (**Table 1**). The dietary lipid supply is of importance for early growth because lipids are the predominant dietary energy source for infants and young children. Lipids provide ≈40–55% of energy in human milk and in modern infant formulas (8). The provision of dietary lipids in amounts at least meeting the needs for tissue storage and obligate fat oxidation is considered advantageous because de novo synthesis of lipids from other substrates, eg, carbohydrates, appears to be limited (9). In contrast to proteins and carbohydrates, lipids can store energy in the body in almost unlimited amounts with a much higher energy deposition per gram of tissue than can be achieved with glycogen or protein. Lipid depots in the body provide energy reserves for periods of reduced dietary intakes that may occur during diseases, eg, infections and diarrhea, or under poor living conditions during times of food shortages. Lipids greatly influence the palatability of foods and modulate their texture, flavor, and aroma. Hence, the quantity and quality of fats in foods may have a direct impact on food consumption.

In children and adolescents, high habitual intakes of dietary fat are associated with a higher prevalence of obesity (10, 11). High dietary intakes of saturated and of *trans* unsaturated fatty acids increase plasma total and LDL-cholesterol concentrations and, even at a young age, may enhance vascular lipid deposition and the occurrence of early vascular lesions (12–14). Therefore, low dietary intakes of saturated and *trans* fatty acids are recommended for healthy children and adolescents to reduce the long-term risk of heart disease (6). Some have also advocated lowering dietary fat intakes in infancy (15, 16). Any considerations on modulating dietary fat and nutrient intakes of childhood populations need to relate to current intakes of foods and nutrients. Here we report data on dietary fat intakes in infants and children in Germany.

SUBJECTS AND METHODS

Data on dietary intakes in infancy were obtained in infants enrolled at birth and followed prospectively through the first year of life in the city of Ingolstadt, Bavaria, Germany. All parents of apparently healthy infants born between November and December 1995 at the Department of Obstetrics, Klinikum Ingolstadt, were invited to participate in the study. Mothers and if available, fathers, were visited in the maternity hospital in the first days after birth by one coauthor. The nature of the study was explained orally and with a written information sheet, and informed verbal consent for participation was obtained. Infants with apparent congenital malformation or disease, including those who required intravenous feeding or medical treatment as inpatients after birth, were excluded from participation. Because the study population

[1] From the Department of Pediatrics, Ludwig-Maximilians-University of Munich, Germany, and Frauenklinik, Klinikum Ingolstadt, Germany.

[2] Presented at the symposium Fat Intake During Childhood, held in Houston, June 8–9, 1998.

[3] Supported in part by Bayerisches Staatsministerium für Arbeit und Sozialordnung, Familie, Frauen und Gesundheit, München, Germany.

[4] Address correspondence to B Koletzko, Division of Metabolic Disorders and Nutrition, University of Munich, Kinderklinik and Kinderpoliklinik, Dr von Haunersches Kinderspital, Lindwurmstrasse 4, D-80337 München, Germany. E-mail: berthold.koletzko@kk-i.med.uni-muenchen.de

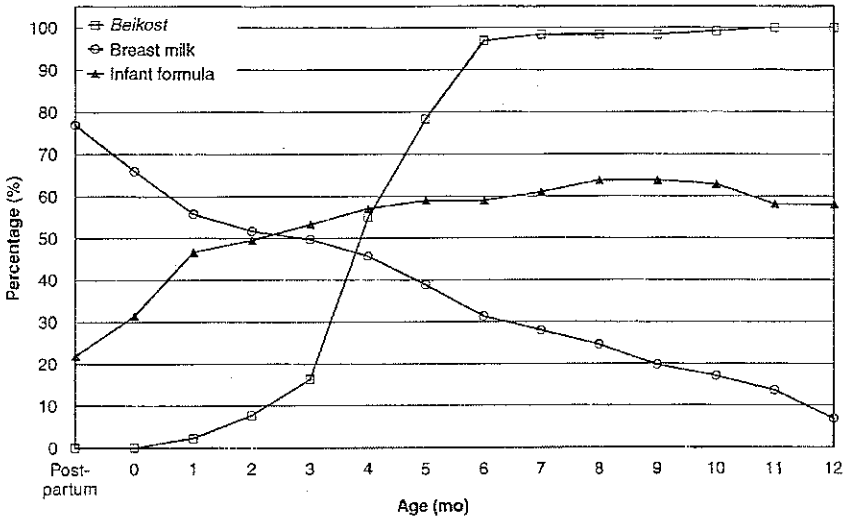

FIGURE 1. Prevalence of feeding human milk, formula, and *Beikost* (complementary solid and liquid foods other than breast milk or infant formula) in 148 German infants followed prospectively from birth to age 12 mo

(Figure 1) Evolution of body weights and nutrient intakes calculated from dietary protocols of the subsample of infants not receiving human milk is shown in **Table 2**.

In the study of primary school children, completed and evaluative dietary records were obtained from 158 children (86 boys and 72 girls) out of the total 170 pupils attending the school (92 9%). The age ranged from 6 to 11 y, with 46 pupils in grade 1 40 pupils in grade 2, 38 pupils in grade 3, and 34 pupils in grade 4. On average, the children consumed >300 g/d of milk and dairy products (**Table 3**). The intake of full-fat milk and yogurt (containing 3 5% fat) was ≈3 times higher than the intake of low-fat milk and yogurt (containing 1.5% fat). Consumption of meat and poultry products was ≈80 g/d and high-fat sausages were consumed twice as much as low-fat sausages. Egg consumption was not high, with an average 1 3 eggs eaten/wk. One-third of the average 60 g/d of bread consumed was contributed by whole-grain products. The average intake of butter was 2 times higher than the consumption of vegetable oil margarine. The

TABLE 2
Body weights and macronutrient intakes of a subsample of non-breast-fed infants during the first year of life

	Age			
	1 mo (n = 16)	4 mo (n = 28)	6 mo (n = 37)	12 mo (n = 36)
Body weight (g)				
$\bar{x}$ ± SD	4835 ± 625	6763 ± 1187	8140 ± 1202	9839 ± 1051
Median	4900	6700	8000	9560
25th Percentile	4500	5800	7175	9000
75th Percentile	5188	7600	8775	10875
Nutrient intake[1]				
Energy				
(kJ)	2224.2 ± 539 5	2483 3 ± 507.7	2516 5 ± 467.1	2938 0 ± 720 7
(kJ/kg)	460 ± 94 3	367 2 ± 85 8	309 2 ± 68 9	298 6 ± 84
Protein				
(g)	12.2 ± 3.5	14 8 ± 4 3	17 7 ± 4 4	23 2 ± 7
(g/kg)	2 5 ± 0 5	2 2 ± 0 5	2 2 ± 0 6	2.4 ± 0 8
(% of energy)	9 4 ± 0 9	10 2 ± 1 9	12 0 ± 2	13 6 ± 3 3
Carbohydrate				
(g)	60 5 ± 15.2	68 6 ± 14 6	75.5 ± 15.3	88 3 ± 26.2
(g/kg)	12 5 ± 2 5	10 1 ± 2 3	9.3 ± 2 0	9.0 ± 3 0
(% of energy)	45 5 ± 1 4	46 9 ± 2 6	50 2 ± 5.0	50 3 ± 8 8
Fat				
(g)	26 5 ± 6 3	28 3 ± 6 0	25 0 ± 5 6	27 8 ± 8.2
(g/kg)	5 5 ± 1 2	4 2 ± 1.1	3 1 ± 1 3	2 9 ± 0 9
(% of energy)	44.8 ± 1.8	42 9 ± 3 8	37 4 ± 4 7	35 7 ± 7 0
Total fluids				
(mL)	541.8 ± 342.9	713.8 ± 251.6	728 8 ± 148.2	646 7 ± 217.8
(mL/kg)	150.3 ± 31.8	121.7 ± 28 1	91 3 ± 24 6	71.7 ± 24 3

[1] $\bar{x}$ ± SD

TABLE 5

Recommended dietary intakes of the European Society for Paediatric Gastroenterology, Hepatology and Nutrition for children aged >2–3 y and for adolescents[1]

Nutrient	Recommendation
Total fat	
Saturated fatty acids	≈8–12% of energy or less
trans Fatty acids	Low intake
Polyunsaturated fatty acids	≈6–10% of energy
Monounsaturated fatty acids	No limitation
Cholesterol	≈300 mg/d or less
Antioxidant vitamins	Generous intake
Sodium	Low intake
Complex carbohydrates	Generous intake

[1] The goal of the recommended intakes is to prevent coronary heart disease Adapted from reference 6

very high mean values for total cholesterol of ≈175 mg/dL (4 53 mmol/L) (Dokoupil et al, unpublished observations 1999). These cholesterol values are markedly higher than the mean values of 160 mg/dL (4 14 mmol/L) found in children of similar age groups in the United States (28) or in Israel (29)

The major dietary factor modulating serum cholesterol concentrations is the dietary intake of saturated fats (8) Serum total cholesterol values of 7–9-y old boys from 6 countries were correlated with average dietary intakes of saturated fatty acids; ≈24% of the intercountry differences in cholesterol values were considered to be due to the variation in saturated fatty acid intake (30, 31). Cholesterol values of Finnish boys with a saturated fatty acid intake of >17% of energy were ≈19% higher than those of Italian boys with a low intake of saturated fatty acids (<11% of energy intake). In a study of children with primary genetic hypercholesterolemia, modification of the habitual dietary intake by repeated counseling aimed primarily at the reduction of saturated fatty acid intake reduced total and LDL cholesterol by ≈15–20 mg/dL (32). Preventive strategies in healthy children aimed at the promotion of a healthy diet and lifestyle, which includes a limited intake of saturated fats, appears prudent (6, 33). Following this concept, the European Society for Paediatric Gastroenterology, Hepatology, and Nutrition has recommended that children from the age of ≥2–3 y and adolescents should aim at a saturated fatty acid intake of <8–12% of energy intake (6). Average intake of *cis* polyunsaturated fatty acids was recommended not to exceed >6–10% of energy, whereas the European Society for Paediatric Gastroenterology Hepatology, and Nutrition saw no reason to advise strict limitations of the intakes of total fat or monounsaturated fatty acids for physically active children with normal body weights (**Table 5**). There is no need to limit the consumption of *cis* monounsaturated fatty acids or oils containing predominantly *cis* monounsaturated fatty acids eg, olive and rapeseed oils, in children with normal body weights because monounsaturated fatty acids do not raise LDL cholesterol (4) However, under the current conditions and dietary habits in central Europe, one practical strategy to achieve a saturated fatty acid intake of ≈8–12% of energy intake is a limitation of total fat intake to <30–35% of energy (6).

Public health efforts in adult populations often emphasize the importance of limiting the dietary intake of saturated and total fats for preventing cardiovascular disease, obesity, type II diabetes, and certain forms of cancer Young families are a segment of the population that appear particularly receptive to such public health messages Although these messages are usually not aimed at infants and young children, parents may project the message into the diets of their infants In an English study in which a group of 1004 women with infants were interviewed, 87.5% of the mothers felt that a low dietary fat intake was important or very important for their infants, and 82.9% stated they sometimes or always avoided giving fat and fatty foods to their children (34). Relatively low fat intakes were observed in several populations of infants, reaching average values as low as 28–30% of energy at 6–12 mo of age (28–31), with ≈10% of infants at lipid intakes that were ≈22% of energy intake (35) The question was raised whether such low fat intakes during infancy are safe (35–37)

Chronic, nonspecific diarrhea (eg, toddlers' diarrhea, pea and carrot diarrhea) was proposed as a potential adverse effect of low-fat diets in young children Chronic, nonspecific diarrhea is considered a motility disorder and may improve after an increase in fat intake, which slows gastric emptying and small-intestinal motility (38).

Foods with a low fat content tend to have a low energy density (19) and concerns were raised that a low fat intake during infancy with a low energy density may have adverse effects on growth (35, 39) Indeed, adverse effects of low-fat diets on weight gain and longitudinal growth in young children were described in some reports (40, 41). A certain proportion of fat in the diet appears to be of value for supporting growth because the biological energy value of dietary long-chain triacylglycerol (≈38 kJ/g) is ≈2.25-fold higher than that of carbohydrates and protein The biological energy value of lipids for growing infants and young children, ie, in the capacity to generate ATP and deposit tissue during growth, may differ even more from nonlipid energy During the first 6 mo of life of a healthy full-term infant, lipids contribute ≈35% to weight gain or ≈90% of the energy retained in newly formed tissue (42). Although infants have the metabolic ability to synthesize lipids for tissue deposition de novo from carbohydrates or proteins, the capacity of this endogenous synthesis appears to be limited (43); moreover, it would result only in nonessential fatty acids with an unfavorable tissue composition Endogenous lipid synthesis requires an increased energy intake because a substantial amount of the energy from dietary carbohydrates and proteins is lost in an energetically futile use of ATP for the synthesis of molecules for storage as metabolic fuel (eg, glycogen, protein) or tissue components (44) For example the synthesis of fat from glucose requires ≈25% of the glucose energy invested for the cost of synthesis whereas the synthesis of fat from fat requires only ≈1–4% of the energy invested (45). The extent of energy loss in vivo is difficult to determine, but a higher thermogenic effect of dietary carbohydrates and proteins compared with long-chain lipids is well known (23, 46) Studies supplying isoenergetic diets with different fat contents actually found a high body weight and fat gain and a low energy expenditure with the high-fat diets (23, 47 48).

Niinikoski et al and Lagstrom et al (15, 16, 49) evaluated the effects of modifying fat intake from the seventh month of life onward by providing dietary counseling aimed at reducing dietary saturated fat intake, on the basis of the assumption that such an early intervention might be beneficial for risk reduction of later heart disease. A total of 1062 infants were recruited in Turku, Finland, and randomly assigned to either an intervention group with intensive diet education or a control

25 Iremblay A, Plourde G, Despres JP, Bouchard C. Impact of dietary fat content and fat oxidation on energy intake in humans Am J Clin Nutr 1989;49:799–805
26. Astrup A Buemann B Christensen NJ Ioubro S Failure to increase lipid oxidation in response to increasing dietary fat content in formerly obese women. Am J Physiol 1994;266:592–9
27 Koletzko B. Childhood diet and prevention of heart disease Eur J Clin Nutr 1991;45(suppl):73–5
28. The Lipid Research Clinics Coronary Prevention Trial results: II. The relationship of reduction in incidence of coronary heart disease to cholesterol lowering. JAMA 1984;251:365–74.
29 Zahavi I. Goldbourt U Cohen-Mandelzweig L. et al Distributions of total cholesterol triglycerides and high-density lipoprotein cholesterol in Israeli Jewish children of different geographic-ethnic origins, ages 9–17 years. Prev Med 1987;16:35–51
30 Knuiman JT, Hermus RJ, Hautvast JG Serum total and high density lipoprotein (HDL) cholesterol concentrations in rural and urban boys from 16 countries Atherosclerosis 1980;36:529–37.
31 Knuiman JT. Westenbrink S van der Heyden L. et al. Determinants of total and high density lipoprotein cholesterol in boys from Finland The Netherlands, Italy the Philippines and Ghana with special reference to diet. Hum Nutr Clin Nutr 1983;37:237–54.
32 Koletzko B, Kupke I Wendel U Treatment of hypercholesterolemia in children and adolescents Acta Paediatr 1992;81:682–5.
33 National Cholesterol Education Program (NCEP). Highlights of the report of the Expert Panel On Blood Cholesterol Levels In Children And Adolescents. Pediatrics 1992;89(suppl):495–501.
34 Morgan JB, Kimber AC Redfern AM Stordy BJ. Healthy eating for infants—mothers' attitudes Acta Paediatr 1995;84:512–5.
35 Koletzko B Response to and range of acceptable fat intakes in infants and children. Eur J Clin Nutr 1999;53(suppl):S78–83
36 Bier DM Brosnan JT Flatt JP. et al. Report of the IDECG Working Group on lower and upper limits of carbohydrate and fat intake International Dietary Energy Consultative Group. Eur J Clin Nutr 1999;53(suppl):S177–8.
37 Michaelsen KF, Hernell O Restriction of fat in the diet of infants. Lancet 1995;345:1117 (letter)
38. Cohen SA Hendricks KM Eastham EJ. Mathis RK Walker WA. Chronic nonspecific diarrhea. A complication of dietary fat restriction. Am J Dis Child 1979;133:490–2.
39 Michaelsen KF Nutrition and growth during infancy The Copenhagen Cohort Study. Acta Paediatr Suppl 1997;420:1–36
40. Lifshitz F Moses N Growth failure A complication of dietary treatment of hypercholesterolemia. Am J Dis Child 1989;143:537–42
41 Hansen D. Michaelsen KF. Skovby F Growth during treatment of familial hypercholesterolemia Acta Paediat 1992;81:1023–5
42. Fomon SJ, Haschke F. Ziegler EE. Nelson SE Body composition of reference children from birth to age 10 years. Am J Clin Nutr 1982; 35(suppl):1169S–75S
43 Flatt JP. The difference in the storage capacities for carbohydrate and for fat, and its implications in the regulation of body weight Ann N Y Acad Sci 1987;499:104–23.
44 Newsholme EA. Substrate cycles: their metabolic, energetic and thermic consequences in man Biochem Soc Symp 1978;43:183–205
45 Flatt JP, Ravussin E, Acheson KJ. Jéquier E Effects of dietary fat on postprandial substrate oxidation and on carbohydrate and fat balances J Clin Invest 1985;76:1019–24.
46 Cinti D Cook L Nagi MN Suneja SK The fatty acid elongation system of mammalian endoplasmatic reticulum Prog Lipid Res 1992;31:1–51.
47. Wood JD. Reid JT. The influence of dietary fat on fat metabolism and body fat deposition in meal-feeding and nibbling rats Br J Nutr 1975;34:15–24
48 Van Aerde JE Sauer PJ, Pencharz PB, Smith JM. Heim I. Swyer PR Metabolic consequences of increasing energy intake by adding lipid to parenteral nutrition in full-term infants Am J Clin Nutr 1994;59:659–62.
49 Lagstrom H. Jokinen E, Seppanen R, et al Nutrient intakes by young children in a prospective randomized trial of a low-saturated fat low-cholesterol diet The STRIP Baby Project. Special Turku Coronary Risk Factor Intervention Project for Babies Arch Pediatr Adolesc Med 1997;151:181–8
50 Barker DJP. Fetal and infant origins of adult disease London: BMJ Publishing Group 1992