REVIEW

Vitamins for babies and young children

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The Welfare Food Scheme has recently been reviewed, and, although changes are being made, free vitamin supplements for children <4 years old will remain an important part of the new "Healthy Start" scheme. Establishing precise daily requirements for vitamins is not easy, and there is considerable individual variation; however, achieving the reference nutrient intake (RNI) should be possible with a healthy balanced diet for all except vitamins K and D, which require additional physiological or metabolic processes. For vitamin K, there is a well-established neonatal supplementation programme, and clinical deficiency is extremely rare. For vitamin D, however, supplementation is inconsistent, and both clinical and subclinical deficiencies are not uncommon in young children in the UK, particularly infants of Asian and Afro-Caribbean ethnic origin, and those who have prolonged exclusive breast feeding and delayed weaning. Most vitamin supplements contain vitamins A, C and D, with or without some of the B group of vitamins. There is clinical and dietary evidence to support vitamin D supplementation and some evidence from dietary surveys that vitamin A intakes may be low; however, there is no evidence to support supplementation of diets of UK children with water-soluble vitamins. Future strategy should aim at education of the public and health professionals regarding dietary intake and physiological aspects of vitamin sufficiency, as well as increasing awareness and availability of supplements, particularly of vitamin D, for those at increased risk of deficiency.

Although vitamin (A, C and D) supplementation has been regarded as an important part of the Welfare Food Scheme since it was introduced in the 1940s, the uptake of vitamin supplements in the UK is patchy, and vitamin deficiency still occurs in early childhood.^{1–3} The Welfare Food Scheme has recently had its first major appraisal starting with a scientific review by the Panel on Child and Maternal Nutrition of the Committee on the Medical Aspects of Food and Nutrition Policy in 1999.⁴ This was followed by discussion and public consultation, resulting in a revised scheme, "Healthy Start" (table 1^{4–5}), which was launched nationwide in November 2006. Healthy Start retains the use of vitamin supplements, but the criteria for their use and entitlement have changed and apply now only to children <4 years old. Thus, it is opportune to review the justification for continuing to recommend vitamin supplements.

VITAMIN PHYSIOLOGY

The fetus can acquire most vitamins from its mother. Water-soluble vitamins—B group and C—are actively transported across the placenta throughout pregnancy, whereas fat-soluble vitamins A, D and E are transferred towards the end of pregnancy. There is negligible transfer of vitamin K.⁶ Breast milk from mothers with adequate status supplies sufficient amounts of most vitamins apart from vitamins K and D. Thus, unsupplemented infants depend on synthesis of vitamin K by gut bacteria, and on antenatally acquired hepatic stores of vitamin D as well as cutaneous synthesis in response to sunlight.⁶

DEFINING RECOMMENDED INTAKES

Table 2 lists the reference nutrient intakes (RNIs)^{7–8} for infants. The RNI is set at 2 standard deviations (SD) above the estimated average requirement and represents the amount estimated to prevent deficiency in 97.5% of a healthy population. Although most infants receiving lower amounts will avoid deficiency, the risk increases as the average daily intake falls. The lower RNI is set at 2 SD below the estimated average requirement and is sufficient for only a few individuals who have low needs.

Setting reference values and determining the risk of nutrient deficiency in children is difficult,^{7–10} and there is a lack of evidence from randomised trials. For babies <6 months old, the estimated average requirement is generally based on the average intake of healthy breast-fed infants. For older infants and children, daily amounts are calculated from metabolic and deprivation studies on adult volunteers and extrapolated on the basis of body weight. A new paradigm, combining studies of nutrient intake alongside measures of specific metabolic function, would allow a more accurate estimation of requirements.¹¹ For reasons arising both from the accuracy of observations and from the confidence in the reference values, comparisons of observed intakes with reference values are not always reliable. Nonetheless, low intakes should alert us to an increased risk of deficiency.

Some of the factors underlying the variability in requirement are evident. For example, dark-skinned children and those whose cultural practice results in little exposure of mother or baby to the sun are at increased risk of vitamin D deficiency. Increased use of sunscreen in response to concern about the damaging effects of sunlight may also compromise dermal synthesis of vitamin D. Other factors such as maternal status and genetically

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Table 1 Summary of entitlements in the Welfare Food Scheme and Healthy Start*

Benefit	Welfare Food Scheme ⁴	Healthy Start ⁵
Milk—7 pints of cows' milk	Pregnant and lactating women; pregnant teenagers only if family already have entitlement; children <5 years; disabled children between 5 and 16 years not attending school; children in daycare (200 ml/day)	Children <5 years in daycare (200 ml/day)
Infant formula	Children aged <1 year (includes some children in low-income families not on IS/IBJSA)	
Vitamins (A, D, C)	Pregnant women; breastfeeding women (up to 1 year postpartum); children <5 years old	Pregnant and lactating women (C, D, folic acid); children <4 years old (A, D, C)
Food vouchers—for cows' milk, infant formula, fresh fruit and vegetables—value £2.80 (double for family with child aged 0–12 months)		Pregnant and lactating women; all pregnant women <18 years; children <4 years

*For families in receipt of income support (IS), income-based jobseeker's allowance (IBJSA) or child tax credit on an income below £14 155.

determined variation are less apparent. This intrinsic variability in requirement of populations underpins the need to set a population reference intake at a higher level than most healthy individuals need. In that sense the recommendation to use supplements constitutes a "safety net".

DIETARY SOURCES

Table 3¹² lists the vitamin content of breast milk and of infant formulas available in the UK. Infant formulas are constituted so that babies receiving 150 ml/kg/day should receive adequate intakes of all vitamins. However, for some formulas the RNI of some vitamins will only be achieved with an intake of 700–800 ml/day. It is recognised that the milieu of infant formula and its effect on intestinal function may alter the efficiency with which nutrients are absorbed and used compared with those in breast milk.⁶ Simple compositional comparisons are not necessarily reliable as a basis for assessment of nutritional adequacy.

CURRENT ADVICE FOR HEALTH PROFESSIONALS REGARDING VITAMIN SUPPLEMENTATION

Perhaps there is potential for confusion about vitamin supplementation in young children, and also in pregnant and lactating women. The Department of Health reports re-emphasise the need for vitamin supplements, particularly (A,

D and C) in certain groups. The basic advice in *Present day practice in infant feeding: third report*¹³ is still mainly applicable, and in the case of vitamin D has recently been reaffirmed by the chief medical officer, because biochemical and clinical rickets remain major public health issues. However, as is evidenced in table 4,^{13–16} although key messages are similar, the details in available advice on vitamin supplementation vary. This may have led to confusion contributing to the relatively low use of vitamin supplements. The Committee on the Medical Aspects of Food and Nutrition Policy reports and the Department of Health report on nutrition and bone health¹⁷ provide guidance on intake of vitamin D and calcium at all ages and highlight pregnancy and lactation as high-risk periods. An RNI of 10 µg/day (400 IU/day) is set for these groups. This is very unlikely to be met by diet, as the average daily intake of women of reproductive age approximates 3 µg/day. Uncertainty has therefore arisen from recent guidance from the National Institute for Clinical Excellence¹⁸ stating that there is insufficient evidence to support routine provision of vitamin D to pregnant mothers.

CURRENT PRACTICE

The Infant Feeding Survey in 2000¹⁹ found a steady decline in the use of vitamin supplements in the preceding decade; only 4% of babies at 4–10 weeks received supplements, 5% at 4–

Table 2 Summary of reference nutrient intakes for vitamins (units/day)

Vitamin	RNI 0–3 months and 4–6 months ⁷	RNI 7–9 months or 10–12 months ⁷	RNI 1–3 years ⁷	Tolerable upper intakes ⁸
A (µg)	350	350	400	800 µg/day (1–3 years)
D (µg)	8.5	7	7	25 µg/day (0–24 months)
E (mg)	0.4 mg/g PUFA	0.4 mg/g PUFA	0.4 mg/g PUFA	10 mg/100 kcal of formula
K (µg)	10	10	10	Not given
B ₁ (thiamine) (mg)	0.2	0.2/0.3	0.5	Not given
B ₂ (riboflavin) (mg)	0.4	0.4	0.6	Not given
Niacin (equivalents mg)	3	4/5	8	2 mg/day (1–3 years)
B ₆ (pyridoxine) (mg)	0.2	0.3/0.4	0.7	5 mg/day (1–3 years)
B ₁₂ (µg)	0.3	0.4	0.5	Not given
Biotin (µg)	Not given	Not given	Not given	7.5/100 kcal
Pantothenate (mg)	1.7	1.7	1.7	1.2/100 kcal
Folic acid (µg)	50	50	70	200 µg/day (1–3 years)
C (mg)	25	25	30	30 mg/100 kcal

PUFA, polyunsaturated fatty acids; RE, retinol equivalents; RNI, reference nutrient intake.

Vitamin A expressed as retinol equivalent: 1 µg RE = 3.33 IU.

Vitamin D (calciferol): 1 µg = 40 IU.

Vitamin E, α-tocopherol equivalent: 1 mg = 1 IU.

Vitamin C expressed as ascorbic acid.

Biotin—no daily reference value given; however, an intake between 10 and 200 µg/day considered safe and sufficient.

Table 3 Vitamin content of breast milk and infant formula (U/100 ml)

Vitamin	Mature human milk ¹²	Infant formula—UK term formula*
A (µg) (retinol equivalents)	60	63–82
D (µg)	0.01	1–1.4
E (mg)	0.35	0.48–1.4
K (µg)	0.21	2.7–6.7
B ₁ (mg)	0.016	0.04–0.1
B ₂ (mg)	0.031	0.06–0.150
Niacin equivalents (mg)	0.23	0.7–0.9
B ₆ (mg)	0.006	0.03–0.06
B ₁₂ (µg)	0.01	0.14–0.3
Biotin (µg)	0.76	1–2
Pantothenate (µg)	260	200–300
Folate (µg)	5.2	3.4–16
C (mg)	3.8	6.9–9.0

*Formulas included: Farleys (Heinz), Milupa, Cow & Gate (Nutricia), SMA (Wyeth) whey-based and casein-based formulas.

5 months and 10% at 8–9 months. Black and Asian babies were more likely to receive supplements: 11% and 17%, respectively, at 4 and 10 weeks, compared with 3% for white babies, and 23% and 17% compared with 4% at 4–5 months. At 8–9 months, supplementation was more common in breast-fed babies (18%) and those fed on cows' milk (17%) than those fed on formula (8%). Although the survey does not identify specific risk factors within each age group, the low proportion of black and Asian babies, and breast-fed infants at 8–9 months, receiving supplements clearly indicate that guidelines are not being followed and it is reasonable to suspect that these low uptakes are partly responsible for the apparent increased prevalence of rickets.

EVIDENCE FOR VITAMIN DEFICIENCY IN UK CHILDREN

Table 5^{20, 21} summarises data for UK children aged 6 months to 2.5 years from two dietary surveys. The National Diet and Nutrition Survey²⁰ studied a representative cohort aged 1.5–4.5 years between July 1992 and June 1993. In all, 2101 children were identified, and between 54% and 88% of the sample contributed data to various components of the study which included parental interview, 4-day weighed dietary

intake record and blood samples. A survey carried out on behalf of the Ministry of Agriculture, Fisheries and Food in 1986 assessed dietary intakes of 488 infants aged between 6 and 12 months by means of a 7-day quantitative diary.²¹ Both surveys showed average dietary intakes of vitamin D consistently below those recommended for age. Plasma levels of 25-hydroxyvitamin D showed seasonal variation, being highest in July to September and lowest in January to March. Levels correlated significantly with intake. In all, 21% of children were receiving nutritional supplements, most including vitamins.²⁰ Although the median intake of vitamin A for children aged 1.5–2.5 years in the National Diet and Nutrition Survey was just above the RNI, it became progressively lower in the older age groups. Overall, nearly 50% of children had vitamin A intake below the RNI of 400 µg, and 7–8% had intakes below the lower reference nutrient intake.²⁰ The higher vitamin intake in younger age groups reflects higher consumption of infant formula, commercial baby foods and fruit drinks.²¹ The intake of B vitamins and vitamin C was well above the RNI.

Vitamin D deficiency is not uncommon in the UK, resulting in rickets and symptomatic hypocalcaemia.^{1–3, 22, 23} Risk factors include Asian or Afro-Caribbean ethnic origin, prematurity and prolonged, exclusive breast feeding with delayed weaning.²⁴ A

Table 4 Guidance on vitamin supplementation

Source of advice	Population	What to give	When to start	Duration of supplementation	Additional notes
<i>Present day practice in infant feeding: third report, 1988</i> ³	All infants and young children	Vitamin A 200 µg Vitamin C 20 mg Vitamin D 7 µg	6 months routinely, but start supplements at 1 month if any doubt about vitamin intake at that time	To at least 2 years, and preferably 5 years	Emphasises importance of vitamin D supplement to pregnant and lactating mothers
<i>Community paediatrics, 2nd edn, 1993</i> ¹⁴	All infants and children	Multivitamin supplement	6 months	At least 2 years, preferably 5 years (endorses DH guidelines)	
<i>Health for all children, 4th edn, 2003</i> ¹⁵	All children Breast-fed and high-risk Asian and Caribbean children on exclusion diets Pregnant and lactating women	Multivitamin supplement Multivitamin supplement Vitamin D	1 year 6 months	Not stated Not stated	Identifies vegetarian and vegan infants as high-risk groups
<i>Weaning and the weaning diet, 1994</i> ¹⁶	Breast-fed infants Formula-fed infants on <500 ml/day All children (unless intake ensured from diet and sunlight)	Vitamins A and D Vitamins A and D Vitamin A and D	6 months 6 months 1 year	5 years 5 years 5 years	Emphasises importance of varied diet, moderate exposure to sunlight and foods and drinks rich in vitamin C

Table 5 Daily dietary vitamin intake of UK children

Vitamin	Intake 6–9 months ²¹	Intake 9–12 months ²¹	Intake 1.5–2.5 years ²⁰
A (RE) (μg/day)	783 (733)	745 (593)	589 (441)
D (μg/day)	4.7 (2.14)	2.2 (0.95)	1.8 (1.0)
E (mg/day)	4.5 (3.7)	3.5 (2.9)	3.9 (3.6)
B ₁ thiamine (mg/day)	1.16 (1.12)	1.03 (0.93)	0.7 (0.7)
B ₂ riboflavin (mg/day)	1.57 (1.53)	1.53 (1.45)	1.2 (1.2)
Niacin equivalents (mg/day)	12.48	12.47	14.7 (14.1)
Pyridoxine (mg/day)	0.82 (0.83)	0.84 (0.79)	1.1 (1.0)
B ₁₂ (μg/day)	3.0 (2.9)	3.4 (3.2)	2.9 (2.5)
Biotin (μg/day)	26.5 (22.0)	23.8 (21.3)	17.1 (16.0)
Pantothenic acid (μg/day)	3.9 (3.7)	3.5 (3.2)	2.7 (2.6)
Folic acid (μg/day)	104	107	120 (114)
C (mg/day)	117 (99)	81 (57)	50.7 (38.4)

RE, retinal equivalent.

Values are given as mean (median).

survey of Asian children aged 2 years living in England showed a high incidence of subclinical hypovitaminosis D.²⁵ Those receiving Department of Health Children's Vitamin Drops (A, D and C)—about 25% of sample—had higher circulating levels of vitamin D. Many Asian adults have low levels of vitamin D, and if pregnant Asian women do not receive supplements their babies are at significantly increased risk of clinical deficiency.²² The recent guidance from the National Institute for Clinical Excellence¹⁸ raised concern among paediatricians who emphasised the need for greater public awareness about vitamin D.²⁶ The Department of Health has recently restated the recommendation that pregnant and nursing mothers should take 10 μg/day supplement of vitamin D.²⁷

Clinical vitamin A deficiency is widespread in children in developing countries and is associated with blindness and with increased mortality and morbidity from infectious diseases. In countries with a high prevalence of mild or severe vitamin A deficiency (defined as serum retinol <0.7 and <0.35 μmol/l, respectively), there is good evidence that giving high doses of vitamin A improves infant survival.^{28–30} There is no such evidence for vitamin A deficiency causing morbidity in the UK.

Vitamin K deficiency bleeding is rare but still occurs, particularly in breast-fed babies who have not received vitamin K at birth. Neonatal vitamin K supplementation has been extensively reviewed after concern in 1992 that babies given intramuscular vitamin K had an increased incidence of childhood cancer.³¹ Subsequent epidemiological studies did not confirm the association.^{32–33} In 1998, the Department of Health issued a statement supporting the use of either a single intramuscular dose of 1 mg of vitamin K to newborn babies (0.4 mg/kg for preterm infants) or an alternative oral regimen of three 2-mg doses during the first 6–8 weeks.³⁴ Infant formula is fortified with vitamin K, providing about 4–10 μg/kg/day.

PROPRIETARY VITAMIN SUPPLEMENTS AVAILABLE FOR BABIES

Table 6^{35–36} lists the contents of some commonly used multi-vitamin supplements currently (or recently) available for prescription in the UK. The Department of Health Children's Vitamin Drops are currently unavailable but previous contents of these drops³⁵ and those being provided for Healthy Start are included in table 5. Vitamin A in "Abidec" is carried in highly refined peanut oil, necessary, according to the manufacturers, to enable it to be incorporated into a water-based solution. The oil is protein free, and not considered to be allergenic. The vitamin A content of "Dalivit" is three times that of Abidec and close to the tolerable upper intake limit of 800 μg⁸ for term infants when given at the recommended dose of 0.3 ml/day.

RECOMMENDATIONS

Risk factors for vitamin deficiency may be identified in the child or in the diet, and both must be assessed. The only vitamin for which there is strong evidence of clinical deficiency in the UK is vitamin D, and dietary intake is generally low in all age groups. Vitamin A intake may be suboptimal in up to 50% of children, but clinical deficiency is not seen. Intake of water-soluble vitamins is satisfactory in the great majority, and there is no evidence for vitamin C deficiency. Diet has only a partial role for vitamins D and K, but is important for all other vitamins. The key steps to ensuring adequate vitamin status of children are thus to give vitamin K at birth, to optimise dietary intake throughout early life, and to maintain a low threshold for providing supplementary vitamin D. The American Academy of Pediatrics recommends that all infants should have a vitamin D intake of at least 5 μg/day (200 IU).³⁷ This should be started within the first 2 months of life as a supplement for breast-fed infants and those fed on <500 ml/

Table 6 Multivitamin supplements in UK: vitamin content of recommended daily dose for infants aged <1 year

Vitamins	Abidec (0.3 ml)	Dalivit (0.3 ml)	Children's Vitamin Drops (5 drops)*	Children's Vitamin Drops—Healthy Start†
A (μg)	200 (667 IU)‡	757 (2500 IU)	214 (700)	233 (770 IU)
D (μg)	5 (200 IU)	5 (200 IU)	7 (280 IU)	7.5 (300 IU)
B ₁ (thiamine) (mg)	0.2	0.5	—	—
B ₂ (riboflavin) (mg)	0.4	0.2	—	—
Nicotinamide (mg)	4	2.5	—	—
B ₆ (pyridoxine) (mg)	0.4	0.25	—	—
C (mg)	20	25	21	20

Abidec 0.6 ml/day recommended for preterm infants.

*Children's Vitamin Drops formulation until approximately 2000 in *A neonatal vade mecum*.³⁵

†Children's Vitamin Drops formulation for Healthy Start; personal communication, Department of Health, 2006.

‡In peanut oil.

day of formula, until a dietary intake of at least 5 µg can be ensured from fortified foods. It is not yet clear whether this dose will be sufficient for all children.³⁸

If vitamin supplements are given, it is important that they do no harm. For those supplements described in table 6, the daily amount of water-soluble vitamins or of vitamin D would probably not exceed recommended upper limits (tables 2 and 3). Vitamin A could quite easily exceed the recommended intake (800 µg/day) if a high-dose supplement is given. It would therefore seem prudent to have a limited number of vitamin preparations available for those children in whom nutritional intake is unlikely to be sufficient. These should err on the lower side for vitamin A, while ensuring a satisfactory dose of vitamin D. Water-soluble vitamin content, if included, should be modest. Vitamin C aids in the absorption of iron. Some risk factors for vitamin deficiency in infancy will continue through early childhood and it will be wise to continue until 4 years of age—as endorsed by Healthy Start.

CONCLUSION

Healthy Start provides an opportunity to review vitamin requirements of UK children. The mainstay of prevention of vitamin deficiency should be a healthy and balanced diet. The vitamin for which supplementation is most important is vitamin D. National strategy should aim at education of the public regarding dietary and environmental issues, while health professionals should be vigilant to detection and prevention in high-risk individuals. Vitamin D should be available for pregnant women, and a low threshold should be adopted for starting supplements in babies shortly after birth.

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