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Micronutrients for child health

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Micronutrients in the diet, such as vitamins and trace minerals, are necessary for increasing the physiological processes in growing children apart from their normal growth and development. Inadequate consumption of micronutrients, such as iron, zinc, potassium, calcium and vitamins leads to severe deficiency and impacts long-term health outcome. Nutritional rehabilitation clinics (NRCs) play a vital role in providing routine facility based care for severe acute malnutrition and medical complications in addition to the dietary assessment of micronutrients. In this comprehensive review, we have elaborated the importance of essentially the trace elements and vitamins, their role in the overall growth and quality health care in children.

Keywords: Minerals, Nutritional rehabilitation clinics, Trace elements, Vitamins

Introduction

Children's nutrition aims to promote their proper growth and development and maintain their present weight and height[1]. Growth during infancy is quick and vital for brain development; hence nutrition has a specialised function at distinct periods of childhood development. As a result, the highest energy and nutritional requirements are proportional to body size. While childhood growth is critical since it accounts for 60% of total growth, it also marks the beginning of puberty. Adult stature and health outcomes can be predicted during the first three years of life. This is the time when growth stunting is most likely to occur. As a result, it is critical to recognize nutrient deficiencies early in infancy and correct them aggressively.

Micronutrients (vitamins and trace minerals) are just as important as macronutrients (fats, carbohydrates, and proteins) for a growing child's optimal growth, development, and physiological activities[2]. As a result, inadequate consumption of minerals and vitamins such as iron, zinc, potassium, calcium, and vitamins will lead to deficiency and a bad long-term health outcome. Nutritional rehabilitation clinics (NRCs) have been set up by the Indian government's Ministry of Health and Family Welfare as part of the National Health Mission (NHM) to provide timely assessment and intervention in children with severe acute malnutrition and treatment of consequences. These NRCs can help children with micronutrient deficiencies by assessing their dietary requirement and providing advice on how to meet them[3]. Anthropometric measurements such as height, weight, dietary history, and practices should be noted for children who visit the hospital. Children with decreased weight, height, and other anthropometric measurements when compared to normal weight and height of children of the same age and sex should be referred to the NRC for further evaluation and management. The NRC nutritionist will ensure that all areas of feeding are addressed, including incorrect feeding, inappropriate feeding practices, and educating and counselling parents on various aspects of malnutrition and the significance of micronutrients, trace elements, and nutrients in children's daily diets. NRC workers should compile a diet plan for the children using readily available foods, fruits, and vegetables, and monitor them on a regular basis. As a result, this research examines the role of various micronutrients in children.

Trace elements as micronutrients

Calcium

Calcium is the most prevalent mineral in the body, almost exclusively found in the bones and teeth[4]. The coagulation cascade, nerve conduction, and muscle stimulation all require calcium[5]. Milk and dairy products are the primary sources of calcium for newborns, with lower quantities coming from grains and fruits after solid foods are introduced[6]. Children who eat strictly vegetarian diets may suffer from calcium deficiency, either alone or in combination

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with a low in vitamin D. Strict vegetarian diets may contain as little as 250 mg of calcium per day, as well as high amounts of calcium-inhibiting compounds including fibre and phytates[7]. Secondary calcium deficiency can occur as a result of steatorrhea, chronic malabsorption disorders, or intestinal or renal calcium metabolism problems.

A daily dosage of 500 to 800 mg is recommended for children aged 1 to 10. Calcium requirements during pubertal growth spurts range from 1000 to 1200 mg per day[8]. Pregnant or nursing women require 400 mg per day[9]. Cal deficiency may lead to muscle cramping, numbness, and tingling in the limbs, a condition termed as Tetany. Chronic deficiency can lead to rickets and osteoporosis.

Magnesium

Magnesium is required for bioenergetic activities biological processes such as fuel oxidation, membrane transport, and signal transmission, and it is involved in the operations functioning of over 300 enzymes[10]. Bone and skeletal muscle contain more than 80% of the total magnesium in the body. Various sources of Mg are legumes, almonds, bananas, and whole grains are all high in magnesium. Magnesium is efficiently absorbed in the intestine, and its equilibrium is regulated by renal tubular reabsorption. Intestinal malabsorption, high gastrointestinal losses by fistulae or continuous suction, or renal illness impacting mediated tubular reabsorption may lead to are the most common causes of deficiency[11]. Irritability, tetany, and hypo or hyper-reflexia are the major symptoms of magnesium insufficiency. Magnesium requirements range from 40 to 50 mg per day for the first six months of age, 60 mg per day for six to twelve months, and around 200 mg per day for older children.

Zinc

Zinc is one of the most imp micronutrients which contribute in various biological processes, including functioning of several metalloenzymes. Many of the enzymes have zinc as an integral part of their structure. Zinc regulates gene transcription and participates in nucleic acid metabolism, protein synthesis, and so cellular development as a component of zinc finger proteins. Zinc-dependent enzymes include thymidine kinase, DNA polymerase, and RNA polymerase[12].

Zinc deficiency is most commonly associated with malnutrition or malabsorption syndromes, which are caused by a lack of zinc in the diet or intestinal illness. Patients on prolonged intravenous feeding without enough trace element supplementation may develop severe zinc deficient disorders. Zinc deficiency causes poor physical growth, FTT and loss of appetite in preschool and school-aged children, while supplementation leads to faster growth in teenagers with intestinal malabsorption and sickle cell disease. Zinc deficiency in adolescents is also associated with delayed sexual maturation and hypogonadism. Other symptoms include such as anemia, anorexia, diarrhea, hair loss, dermatitis, reduced immunological function, poor wound healing, and skeletal abnormalities[13]. Children's daily needs are typically between 3.5 and 5.0 mg[14].

Copper

Copper is an essential component of several metalloenzymes which are integral parts of oxidative metabolism. Ceruloplasmin, a glycoprotein with eight copper atoms per molecule, is responsible for 95% of the ion in blood[15]. Meats, liver, fish, nuts, and seeds are the most common sources of copper. Pesticides and pollution of water by pipes and cooking utensils may introduce additional copper into the food chain. There are fewer chances to have a primary dietary shortage. Malabsorption syndromes, liver illness, peritoneal dialysis, and other disorders that cause high copper losses can cause secondary deficiency. Rnicrocytic, hypochrornic anaemia refractory to iron therapy, neutropenia, and osteoporosis are the common symptoms of Cu deficiency[16]. Copper deficiency shortens the lifespan of erythrocytes and severely impacts the it difficult to mobilization of iron from the liver and bone marrow. Deficiency may cause skeletal diseases such as periosteal elevation, alterations in the metaphyses of long bones, and submetaphyseal fractures, flaring of the anterior ribs, and spontaneous rib fractures. Pallor, depigmentation of the skin and hair, large dilated superficial veins, seborrheic dermatitis-like lesions, anorexia, diarrhea, and failure to thrive include some of the additional anomalies of Cu deficiency among infants[17].

Selenium

Glutathione peroxidase, an antioxidant found in red blood cells and other organs, contains selenium. Glutathione peroxidase scavenges free hydroperoxides produced during the oxidation of fatty acids, protecting the cell from free radical damage. Keshan disease, which manifests as a cardiomyopathy in early children, is caused by severe deficiency of selenium[18]. Myopathies of the skeleton have also been documented. Macrocytosis and hair pigment loss are symptoms of mild deficiency.

Chromium

Chromium deficiency has been linked to glucose intolerance, which exacerbates malnutrition in early infants. Chromium helps maintain glucose homeostasis by potentiating insulin action and perhaps enhancing receptor binding[19]. Symptoms of chromium deficiency include glucose intolerance, peripheral neuropathy, and evidence of altered nitrogen and lipid metabolism in the context of total parenteral alimentation[20].

Iodine

Iodine deficiency diseases (IDD) are the consequences of iodine deficit in a population that can be avoided by providing enough iodine intakes. Iodine shortage can cause a variety of problems such as abortions, stillbirths, congenital abnormalities, and endemic cretinism[21]. Increased prenatal mortality, neonatal goitre, endemic mental impairment, and neonatal hypothyroidism are some of the probable issues in neonates due to I deficiency. Furthermore, I shortage may lead to goitre, decreased mental function, subclinical hypothyroidism, and delayed physical growth in children and adolescents[22]. The daily iodine limit for preschool children (0 to 59 months), school children (6 to 12 years) and for adults is respectively, 90 mg, 120 mg 150 mg[23].

Iodization of salt is the most feasible method of iodine deficit treatment. Other treatments include taking iodized oil capsules every 6-10 months, administering iodine solutions such as Lugol iodine at regular intervals, and iodizing water supplies by adding iodine solution directly to the water supply[24].

Iron

Iron deficiency is still a significant dietary issue for newborns and young children. Anemia caused by iron deficiency is linked to poor mental and physical performance, including physical coordination and ability, cognitive capacities, and social and emotional development. The impact of iron deficiency may differ among the different age groups of children. Iron deficiency in young children has substantial and potentially irreversible health repercussions. Severe anaemia may result when a child's haemoglobin level is more than two standard deviations below the mean for his or her age and gender[25].

Table 1 briefly mentions about details of required trace elements, their physiology, effects of both deficiency and excess and also dietary source.

Vitamins as micronutrients

Fat soluble

Vitamin A (retinol) refers to biologically active substances that are structurally linked to retinol. Six different isomers of retinol are known. The most efficient precursor is all-trans-carotene, which is commonly available. Oils extracted from shark and cod liver is the best sources of preformed vitamin A. Other good sources of vitamin A include carrots, dark-green leafy vegetables, squash, oranges, and tomatoes[26]. Preformed vitamin A is supplemented in many processed foods and infant formulae to ensure its sufficient intake. Vitamin A's recommended daily allowance is as follows: (i) newborns weighing 300-400 g; (ii) children weighing 400-600 g; (iii) teenagers weighing 750 g.

Vitamin A's key activities include: (i) maintaining eyesight, particularly night vision; (ii) maintaining epithelial tissues; and (iii) controlling gene expression to differentiate distinct tissues, notably during reproduction and gestation. The most frequent symptoms of vitamin A deficiency in babies include Bitot spots, xerophthalmia, keratomalacia, corneal opacities, hyperkeratosis, development failure, and mortality are all.

Oral vitamin A at doses of 50,000, 100,000, and 200,000 IU is generally used to treat vitamin A deficiency in children aged 6 months, 6-12 months, and >1 year, respectively[27]. The next day and four weeks later, the identical dose is given.

Children aged 1 to 5 years are recommended an oral dosage of 200,000 IU vitamin A every six months as part of the Ministry of Health and Family Welfare's National Vitamin A Prophylaxis programme. Vitamin A is now exclusively given to children under the age of three because they are at the greatest risk, and the first two doses are given in conjunction with normal immunisation to improve the coverage. As a result, at 9 months, a dose of 100,000 IU is given with the measles vaccine, and at 15-18 months, a dose of 200,000 IU is given with the DPT booster. In endemic areas, three further doses are given at 24, 30, and 36 months[28].

Vitamin D

Secosteroids, which play a key role in calcium and phosphorus homeostasis, are referred to as vitamin D. Vitamin D is made up of mainly two prohormones: vitamin D2 (ergocalciferol; derived from plants) and vitamin D3 (cholecalciferol; derived from animals), and their derivatives[29]. An active transport mechanism in the duodenum absorbs vitamin D. Vitamin D is

Table 1 — Trace elements, their physiology, effects of deficiency and excess, and dietary sources

Element	Physiology	Effects of deficiency	Effects of excess	Dietary sources
Chromium[19,20]	Potentiates the action of insulin	Impaired glucose tolerance, peripheral neuropathy, and encephalopathy	Unknown	Meat, grains, fruits and vegetables
Copper[15-17]	Absorbed via specific intestinal transporter. Circulates bound to Ceruloplasmin. Enzyme cofactor (superoxide dismutase, cytochrome oxidase and enzymes involved in iron metabolism and connective tissue formation)	Microcytic anemia, osteoporosis, neutropenia, neurologic symptoms, depigmentation of hair and skin.	Acute: nausea, emesis, abdominal pain, coma and hepatic necrosis. Chronic toxicity (liver and brain injury) occurs in Wilson disease and secondary to excess intake.	Vegetables, grains, nuts liver, legumes, corn oil
Calcium[4-9]	Structural component of skeleton	Hypocalcaemia	Hypercalcemia	Milk, cheese, dairy foods
Iodine[21-24]	Component of thyroid hormone	Hypothyroidism	Hypothyroidism and goiter; maternal excess can cause congenital hypothyroidism and goiter	Saltwater fish, iodised salt
Iron[25]	Component of hemoglobin, myoglobin, cytochromes, and other enzymes	Anemia, decreased alertness, and impaired learning	Acute: nausea, vomiting, diarrhea, abdominal pain	Meat, fortified foods
Magnesium[10,11]	ATP, GTP synthesis	Diarrhea, diabetes, Crohns disease	Magnesium toxicity	Nuts, beans, grains
Selenium[18]	Enzyme cofactor (prevents oxidative damage)	Cardiomyopathy, myopathy	Nausea, diarrhea, garlic odor	Meat, seafood, wholegrains, garlic
Zinc[12-14]	Enzyme cofactor Constituent of zinc-finger proteins, which regulate gene transcription.	Decreased growth, dermatitis of extremities, and around orifices, impaired immunity, poor wound healing, diarrhea, hypogonadism	Abdominal pain, diarrhea, vomiting, can worsen copper deficiency	Meat, shellfish, wholegrains, legumes, cheese

primarily obtained through skin synthesis in response to ultraviolet B (UVB) sun irradiation (wavelength 290-315 nm)[30]. Vitamin D obtained from food amounts for 5-10% of total vitamin D. Fish and fish oils, egg yolk, fortified cereals, and margarine are all good sources of omega-3 fatty acids. In the absence of food fortification, the quantity in vegetable sources is insignificant, and thus, the dietary intakes are low. Human milk has only 30-40 IU per litre. Vitamin D concentration in breast milk can be increased by exposing the nursing mothers to sunlight and with the usage of vitamin D supplements[31]. Infants should get 5 g (200 IU) of vitamin D per day, while children should get 10 g (400 IU) per day. Human milk is generally deficit in vitamin D and has only 30-40 IU per litre, largely from 25(0H) D3. As a result, breastfed newborns require an additional source of vitamin D. Table 2 provides physical and metabolic properties and food sources of fat soluble vitamins.

Vitamin E

Vitamin E (tocopherol) is a membrane bound antioxidant. Normal infants require about 0.4 grams of vitamin E per kilogramme of body weight each day[32] however, the premature newborns require 15 to 20 mg per day. From birth to two years of age, the Recommended dietary allowance (RDA) for tocopherol increases from 3 to 6 mg. Vegetable oils (com, cottonseed, safflower) and margarine are common sources of vitamin E. Leafy vegetables and nuts are also considered good sources like the breast milk and colostrum.

Vitamin K

Vitamin K is a general word for procoagulant compounds of 2-methyl-l, 4-naphthoquinone[33]. In plants, vitamin Kl (phylloquinone) is the homolog of vitamin K. In the intestines, microorganisms produce vitamin K2 (menaquinone). Vitamin K's principal function in the liver is as a cofactor in the post-translational carboxylation of glutaric acid to generate glutamate. Vitamin K produces y-carboxyglutamates by carboxylating glutaric acids in translation products of vitamin K-dependent proteins[34]. Proteins C and S are anticoagulant proenzymes, whereas factors II (prothrombin), VII, IX, and X are procoagulant proenzymes[35]. These proteins facilitate the chelation of calcium ions to glutamate and platelet phosphatide,

Table 2 — Physical and metabolic properties and food sources of fat soluble vitamins

Names and synonyms	Characteristics	Biochemical action	Effects of deficiency	Effects of excess	sources
		Vitamin D[4,8,27,29-31]			
Vitamin D3(3-cholecalciferol), which is synthesized in the skin and vitamin D2(from plants or yeasts) are biologically equivalent; 1μ=40 IU vitamin D	Fat-soluble stable to heat, acid, alkali, and oxidation; bile necessary for absorption; hydroxylation in the liver and kidney necessary for activity	Necessary for GI absorption of calcium; also increases absorption of phosphate; direct action on bone, including mediating resorption	Rickets in growing children; osteomalacia; hypocalcemia can cause tetany and seizures	Hypercalcemia, which can cause emesis, anorexia, pancreatitis, hypertension, arrythmias, CNS effects, polyuria, nephrolithiasis, renal failure	Exposure to sunlight;mfish oils, fatty fish, egg yolks, vitamin D-fortified formula, milk cereals, bread
		Vitamin E[32]			
Group of related compounds with similar biologic activities; α-tocopherol is the most potent and most common form	Fat soluble; readily oxidized by oxygen, iron, rancid fats; bile acids necessary for absorption	Antioxidant; protection of cell membranes from lipid peroxidation and formation of free radicals	Red cell hemolysis in premature infants; posterior column and cerebellar dysfunction; pigmentary retinopathy	Unknown	Vegetable oils, seeds, nuts, green leafy vegetables, margarine
		Vitamin K[33-36]			
Group of naphthoquinones with similar biologic activities; K1 (phylloquinone) from diet; K2 (menaquinones) from intestinal bacteria	Natural compounds are fat soluble; stable to heat and reducing agents; labile to oxidizing agent, strong acids, alkali, light; bile salts necessary for intestinal absorption	Vitamin K- dependent proteins include coagulation factors II, VII, IX, and X; proteins C, S, Z; matrix Gla protein, osteocalcin	Hemorrhagic manifestations; long term bone and vascular health	Not established; analogs (no longer used) caused hemolytic anemia, jaundice, kemicterus death	Green leafy vegetables, liver, certain legumes, and plant oils; widely distributed

which is required for the functioning of coagulation cascade. The normalisation of prothrombin and other factors in infants necessitates 3-5 g of vitamin K/day as the breast milk only contains 2 g/L phylloquinone, breastfed babies need to get extra vitamin K to prevent newborn hemorrhagic illness. The demand rises from 5 g/day at birth to 10 grams per day at two years, and then to 10-30 g/day in older children. Phylloquinone is abundant in green leafy vegetables, at intermediate level in animal meals however, cereals are deficient in the vitaminK[36]. The bacterial gut flora can synthesise enough of the vitamin to meet daily requirements.

Water soluble vitamins

Thiamine (*Vitamin B1*)

The recommended daily carbohydrate requirement of thiamine for children is 0.4 mg/1000 kcal. Unrefined or fortified cereal grains, enriched bread items, organ meats (liver, kidney), and legumes are good sources of thiamine. Heat, sulphites, pasteurisation, and sterilisation degrade the thiamine, however, freezing causes relatively less loss. Human milk has a low thiamine concentration (16 g/mL) compared to cow milk (40-50 g/mL). When the dietary intake of thiamine is less than one mg/day, beriberi develops[37]. Beriberi can appear as dry, moist, or acute beriberi, each with its own set of symptoms. In all the malnutrition cases, thiamine deficiency is the major cause of beriberi. The diagnosis is confirmed by measuring 24 h urine thiamine excretion, which in normal children ranges from 40 to 100 g/day, and in case of deficiency it is less than 15 g/day. Within 24-48 h of starting thiamine therapy, neurologic and cardiac symptoms disappear. The use of thiamine (5 mg/day) in the treatment of mild beriberi is effective. Children with severe illnesses should receive 10 mg intravenously twice a day. Higher doses with aggressive treatment of congestive heart failure are required in the management of fulminant heart disease.

Riboflavin (*Vitamin B2*)

Riboflavin is a flavoprotein found in a wide range of plants. Broccoli, spinach, and asparagus, as well as meat, chicken, fish, and dairy products, are good sources of vitamin B2. Pasteurization does not destroy riboflavin since it is resistant to oxidation and heat. Riboflavin is found in 40-70 g/100 kcal in human milk and 250 g/100 kcal in cow milk[38]. To boost the concentration of riboflavin in breast milk, mothers are recommended riboflavin supplements. For babies, 0.4 mg/1000 kcal is advised, while for children, 0.8-1.2 mg/1000 kcal is recommended. Inadequate riboflavin intake or its malabsorption causes riboflavin deficiency. Photophobia, glossitis, angular stomatitis, seborrheic dermatitis, corneal vascularization, and cataracts are the common symptoms of ariboflavinosis[39]. Anorexia, weight loss, weakness, disorientation, and confusion are all nonspecific symptoms. For several weeks, children are given one mg riboflavin thrice a day, and newborns are given 0.5 mg twice a day. Vitamin therapy at therapeutic levels aids in the quick improvement of corneal lesions.

Niacin (*Vitamin B3*)

Niacin refers to both nicotinic acid and nicotinamide, which are biologically identical vitamins[40]. All species produce this vitamin, and the conversion ratio of tryptophan to nicotinic acid is 60:1, allowing vast levels of tryptophan to meet niacin requirements. Good sources include milk, cereals, green vegetables, fish, coffee, and tea[41]. Heat does not affect the vitamins. Niacin content in human milk is 30 mg/100 kcal, compared to 0.12 mg/100 kcal in cow milk. The recommended intake ranges from 6.4 to 8 niacin equivalents/1000 kcal, with human milk providing approximately 8 NE/1000 kcal. Pellagra, the pathognomonic skin alteration, is caused by a niacin deficit[42]. Pellagra is treated with a daily dose that is roughly 10 times the normal dietary intake. Pellagra can be avoided by eating a high-protein diet that includes foods high in tryptophan and niacin[43].

Pyridoxine (*Vitamin B6)*

Pyridoxine aids in the digestion of meals, as well as the metabolism of proteins and vital fatty acids. It is important in the development of antibodies against bacterial illnesses and activates several enzyme systems. It is linked to cardiovascular health because it reduces homocysteine production[44]. It's also needed for vitamin B12 absorption and the creation of monoamine neurotransmitters like serotonin, dopamine, noradrenaline, and adrenaline. Lack of pyridoxine may lead to anemia, neuropathy, convulsions, skin disorders, and mouth sores [45]. Patients using Isonicotinic acid hydrazide (NH) (isoniazid) are given 10-50 mg of pyridoxine per day to prevent peripheral neuropathy and other neurologic side effects. Yeast, sunflower seeds, wheat germ, soya beans, and walnuts are all good sources of vitamin B6.

Cobalamin (*Vitamin B 12*)

Although cyanocobalamin is the most prevalent commercially accessible form of vitamin B12, methylcobalamin and 5'-deoxyadenosyl cobalamin are the active forms in tissues[46]. Only microbes can produce vitamin B12. Cobalamin is found in animals because it is either consumed with microorganisms or generated by bacteria in the upper intestine. Organs including the liver, kidney, heart, and muscle meat have the highest quantities, and the clams and oysters are considered the good sources[47]. Vitamin B12 consumption for babies should be 0.3 g per day. Adolescents should get 2.0 g/day, whereas older children should get 0.5-1.5 g/day. Any mixed diet will meet these requirements. Megaloblastic anaemia is caused by a vitamin B 12 deficiency, which, when combined with a folic acid deficit, can result in faulty DNA synthesis and a variety of neurological symptoms. The anaemia is macrocytic, and blood tests reveal nucleated RBC with megaloblastic morphology. Red cell folate levels are low, whereas serum LOH levels are high[48]. Table 3 provides physical and metabolic properties and food sources of water soluble vitamins.

Pantothenic Acid

Pantothenic acid (vitamin B5) is found in almost all naturally occurring foods, and bacteria make it from pantoic acid and alanine. Vitamin B5 deficit generally coexists with other vitamin deficiencies in cases of extreme starvation. For newborns, a daily dosage of 2-3 mg is recommended, while for children, a daily intake of 3-5 mg is recommended[49].

Vitamin C

Vitamin C (ascorbic acid), which is chemically related to glucose, has a remarkable ability to reduce oxidation in a reversible manner. Vitamin C is not synthesised by humans or other primates. Vegetables (cauliflower, broccoli, cabbage) and fruits are good sources (berries, citrus) of vitamin C. Cooking can deplete vitamin C, although it is preserved in canned and frozen foods[50]. Human and cow milk contain 5 to 15 mg/100 kcal and 0.2-2.0 mg/100 kcal of vitamin C, respectively. For babies, the daily need is 30-40 mg, while for youngsters, it is 40-70 mg. Vitamin C is a powerful reducing agent that also aids in electron transport in biological systems. Ascorbic acid is required for normal leukocyte, fibroblast, osteoblast, and microsomal functioning and is involved in the metabolism of carnitine, serotonin, and folate[51]. Immune response, detoxification, collagen production, and wound healing are affected by ascorbic acid. Scurvy is

Table 3 — Physical and metabolic properties and food sources of water soluble vitamins

Names and synonyms	Biochemical action	Effects of deficiency	Treatment of deficiency	Causes of deficiency	Diet/source
Thiamine (vitamin B1)[37]	Coenzyme in carbohydrate metabolism Nucleic acid synthesis Neurotransmitter synthesis	Neurologic (dry beriberi) irritability, peripheral neuritis, muscle tenderness, ataxia Cardiac (wet beriberi): tachycardia, edema, cardiomegaly, cardiac failure	3-5 mg/day PO thiamine for 6 wk	Polished rice-based diets Malabsorptive states Severe malnutrition Malignancies Alcoholism	Meat, liver, rice (unpolished), wheat, cereals, legumes
Riboflavin (Vitamin B2)[38,39]	Constituent of flavoprotein enzymes important in redox reactions: amino acid, fatty acid, and carbohydrate metabolism and cellular respiration	Glossitis, photophobia, lacrimation, corneal vascularization, poor growth, cheilosis	3-10mg/day PO riboflavin	Severe malnutrition Malabsorptive states Prolonged treatment with phenothiazines, probenecid, or OCPs	Milk, milk products, cereals, vegetables
Niacin (Vitamin B3)[40,41,42,43]	Constituent of NAD and NADP, important in respiratory chain, fatty acid synthesis, cell differentiation, and DNA processing	Pellagra manifesting as diarrhea, symmetric scaly dermatitis in sun exposed areas and neurologic symptoms of disorientation and delirium	50-300 mg/ day PO niacin	Predominantly maize based diets Anorexia nervosa Carcinoid	Meat, poultry products, cereals, legumes, green vegetables
Pyridoxine (Vitamin B6)[44,45]	Constituent of coenzymes for amino acid and glycogen metabolism, heme synthesis, steroid action, neurotransmitter synthesis	Irritability, convulsions, hypochromic anemia, failure to thrive, oxaluria	5-25 mg/day PO for deficiency states 100 mg IM or IV for pyridoxine dependent seizures	Prolonged treatment with INH, penicillamine, OCPs	Fortified foods to eat, poultry products, bananas, potatoes
Pantothenic acid (Vitamin B5)[49]	Component of coenzyme A and acyl carrier protein involved in fatty acid metabolism	Experimentally produced deficiency in humans: irritability, fatigue, numbness, paresthesias, 9burning feet syndrome), muscle cramps		Isolated deficiency extremely rare in humans	Beans, meats, poultry products, sea foods, eggs, soyabean, mustard
Cobalamin (Vitamin B12)[46,47,48]	As deoxyadenosylcobalamin, acta as cofactor for lipid and carbohydrate metabolism As methylcobalamin, important for conversion of homocysteine to methionine and folic acid metabolism	Megaloblastic anemia, irritability, developmental delay, regression, involuntary movements, hyperpigmentation	1000 μ IM Vitamin B12	Vegan diets, malabsorptive states Crohn disease Intrinsic factor deficiency (pernicious anemia)	Sea foods, poultry products, yolks, meat, fortified foods
Ascorbic acid (Vitamin C)[50,51,52]	Important for collagen synthesis, metabolism of cholesterol and neurotransmitters Antioxidant functions and non heme iron absorption	Scurvy manifesting as irritability, tenderness and swelling of legs, bleeding gums, follicular hyperkeratosis, and poor wound healing	100-200 mg/day PO ascorbic acid for up to 3 months	Predominantly milk based (non-human milk) diets Severe malnutrition	Citrus fruit juice, pepper, berries, tomatoes, cauliflower, green leafy vegetables

(*Contd.*)

caused by a long-term vitamin C deficiency. It most commonly affects people who are deprived of citrus fruits, fresh vegetables, or the vitamins due to cultural or geographic factors[52]. Taking 100-200 mg of vitamin C orally or parenterally improves symptoms quickly and effectively. The similar effect can be achieved by drinking 100 mL of orange juice or tomato pulp every day.

Conclusion

Parents should be appropriately counselled and educated about the significance of micronutrients, trace elements, and vitamins in their children's overall physical and mental development, as well as the role of these micronutrients in reducing disease burden. Younger children should be encouraged to consume adequate amounts of easily available fruits, vegetables, and animal foods in order to avoid deficiency disorders caused by micronutrient, trace element, and vitamin deficiencies. Although it is impossible to meet the RDA for every element, efforts should be taken at various levels to ensure that these micronutrients and vitamins are obtained as much as possible from our daily diet. It is now feasible to monitor children's nutritional intake, reassess their growth and development, and give suitable education and counselling about daily dietary needs of young and older children, thanks to the advent of NRC.

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