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Biochemical functions of micronutrients

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Introduction

Micronutrients are vitamins and minerals required in small amounts that are essential for healthy development and growth. They have great importance for a healthy living.[1] Micronutrients play a central part in metabolism and in the maintenance of tissue function.[2]

Vitamins are organic substances that function as regulators in the body. They are divided into two groups: fat soluble vitamins (vitamin A, D, E and K) and water soluble vitamins (Vitamin B1, B2, B6, B12, Vit C, Folic acid, etc.).[3,4]. Fat soluble vitamins are stored in the fat tissues and liver, water solube vitamins are found in the aqueous parts of the cells, inside the compartments such as mitochondria which is responsible for oxidation of carbohydrates and fats for energy.[5] There are many benefits of vitamins and they have a major impact on our overall health.

Minerals are essential nutrients that represent about 5-6% of the total body weight. There are two major groups of minerals depending on the percentage of body weight and the amount required in diet. Major or macro-minerals are present in the body at levels greater than 0.01% and they are required in the body in amounts greater than 100mg/day. They function in both structural and regulatory roles. Some of the major minerals include calcium, phosphorus, sodium, potassium, magnesium and chloride. Trace or micro-minerals are present in the body at levels less than 0.01% and they are required in amounts less than 50mg/day, therefore they function primarily in regulatory roles.[5] Trace elements include iron, cobalt, chromium, copper, fluordie, iodine, manganese, selenium, zinc and molybdenum. They are importantant in many metabolic events and also for healthy immune functions.

Although micronutrients are found naturally in a variety of plant and animal based foods, they can be synthesized in the laboratory that are used in fortified foods.[6] Micronutrients are important for human body because they are required for vital processes in the human body and their deficiencies can cause serious health problems.[7]

The World Health Organization (WHO) has reported that more than 2billion people in the world today suffer from micronutrient deficiencies caused largely by dietary deficiencies of vitamins and minerals, primarily iodine, iron, vitamin A, vitamin D and zinc, with important health consequences.[8] The importance of these deficiencies for the public health lies upon their magnitude and their health consequences, especially in pregnant women and young children, as they might affect fetal and child growth, cognitive development and resistance to infections.

Micronutrient deficiencies are globally important problems which are not always clinically apparent or dependent on food supply and consumption patterns. They might be associated with physiologic effects that can be lifethreatening or more commonly damaging to optimal health and functions of the body.[8] Iron deficiency is the most prevalent nutrition problem in the world.[8]

Other than a low dietary intake, important causes of maternal near miss (MNM) include poor bioavailability from foods (especially for minerals), frequent infection with parasites, diarrhea, and various malabsorption disorders. The presence of any of these risk factors can lead to an underestimation of the prevalence of deficiency in a population if this is calculated on the basis of micronutrient intakes alone.

Biochemical functions of micronutrients are reported as follows[9]

1. Cofactors in metabolism-trace elements are frequently involved in modulating enzyme activity or are an integral part of enzyme prosthetic groups.
2. Coenzymes in metabolism-many vitamins or metabolites of vitamins are required to play an active part within complex biochemical reactions. These reactions are critical to intermediary metabolism and ensure utilisation of the major nutrients to provide energy, proteins and nucleic acids.
3. Genetic control-zinc “fingers” are transcription control factors that bind to DNA and regulate transcription of receptors for steroid hormones and other factors.
4. Antioxidants-much of the popular interest in the micronutrients stems from the recognition that many of the micronutrients have antioxidant properties.

Deficiency conditions, their worldwide prevalence and toxicity of some important micronutrients are presented in Table 1.

It was reported that adequate intakes of most micronutrients can be obtained from a typical diet in the UK in adults.[10–13] Daily recommended intake values for vitamins and minerals for adults are presented in Table 2 & 3 respectively.

Clinical benefits can be obtained by supplementation of micronutrients for individuals who are severely depleted however regarding to the micrograms to milligrams ranges of their daily intake values, excess amounts can be even harmful. Consequently, it is recommended to consume micronutrients in proper amounts to balance the adequate levels for optimum health.

Table 1 Deficiency conditions, their worldwire prevalence and toxicity of some important micronutrients.

Micronutrient	Deficiency	Deficiency prevalence	Toxicity
Iron	Anaemia; low levels of haemoglobin, ferritin reduced learning and work capacity, increased maternal and infant mortality, low birth weight	2billion	Bloody diarrhoea, vomiting, sometimes liver failure
Zinc	Poor growth and sexual maturation, anaemia, enlarged liver and spleen, skin rash, lethargy pregnancy outcome, impaired growth (stunting), genetic disorders, decreased resistance to infectious diseases	Estimated high in developing countries	Nausea, vomiting, epigastric pain, abdominal cramps, diarrhoea, central nervous system deficits, copper deficiency
Fluoride	Mottling of teeth; fluorosis Increased dental decay, affects bone health	Widespread	Excess tooth decay
Iodine	Goiter, hypothyroidism, iodine deficiency disorders, increased risk of stillbirth, birth defects infant mortality, cognitive impairment	2billion at risk	None
Calcium	Decreased bone mineralization, rickets, osteoporosis	Insufficient data, estimated to be widespread	Rare
Selenium	Fragile red cells; cardiomyopathy, heart and skeletal muscle degeneration, cardiovascular risk and increased cancer	Insufficient data, common in Asia, Scandinavia, Siberia	Neuromusculer defects; liver and muscle damage
Copper	Anaemia; poor wound healing; lethargy; depressed collagen synthesis	Insufficient data, estimated to be widespread	Rare
Vitamin A	Night blindness, xerophthalmia, increased risk of mortality in children and pregnant women	254million preschool children	Hypervitaminosis A
Folate (vitamin B9)	Megaloblastic anemia, neural tube and other birth defects, heart disease, stroke, impaired cognitive function, depression	Insufficient data	Rare
Cobolamine (vitamin B12)	Megaloblastic anemia (associated with Helicobacter pylori induced gastric atrophy	Insufficient data	Rare
Thiamine (viamin B1)	Beriberi (cardiac and neurologic), Wernicke and Korsakov syndromes (alcoholic confusion and paralysis)	Insufficient data, estimated as common in developing countries and in famines, displaced persons	Rare
Vitamin D	Rickets, osteomalacia, osteoporosis, colo rectal cancer	Widespread in all age groups, low exposure to ultra violet rays of sun	Bone demineralization, Soft Tissue Calcifications
Vitamin B6 (pyridoxine)	Dermatitis, neurological disorders, convulsions, anemia, elevated plasma homocysteine	Insufficient data, estimated as common in developing countries and in famines, displaced persons	Rare
Riboflavin (Vitamin B2)	Non specific – fatigue, eye changes, dermatitis, brain dysfunction, impaired iron absorption	Insufficient data, est. to be commonin developing countries	None

Table 2 Recommended vitamin intake for adults

Vitamins	Food sources	Daily Value
Thiamin (Vit B1)	Whole grains, seeds, nuts, legumes, fortified foods	1.1-1.2mg
Riboflavin (Vit B2)	Liver, dairy products, whole grains, leafy greens, meat, eggs	1.1-1.3mg
Niacin (Vit B3)	Meat, legumes, peanut, can be made from tryptophan	14-16mg NE
Pantothenic acid (B5)	Meat, legumes, whole grains, widespread in food	5mg
Vit B6	Meat, fish, poultry, legumes, whole grains, nuts, seeds	1.3-1.7mg
Vit B12	Animal products, liver, mussel	2.4µg
Vit C	Citrus fruits, green peppers, strawberries, rosehip, parsley	75-90mg
Biotin	Liver, egg yolk, synthesized in the gut	30µg
Folic acid	Leafy green vegetables, legumes	400µg

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Table Continued....

Vitamins	Food sources	Daily Value
Vit A	Liver, butter, eggs, carrots, leafy greens, cantaloupe	700-900 µg
Vit D	Egg yolk, liver, tuna, somon, synthesis from sunlight	5-15µg
Vit E	Vegetable oils, leafy greens, seeds, nuts	15mg
Vit K	Synthesis by intestinal bacteria, vegetable oils, leafy greens	90-120µg

NF, Niacin equivalent.[2,9]

Table 3 Recommended major minerals intake for adults.[2,9]

Minerals	Food sources	Daily value
Sodium	Table salt, processed foods, meat, seafood	1500mg
Potassium	Fresh fruits, vegetables, potato, banana, meat, nuts, whole grains	4700mg
Chloride	Table salt, processed foods	2300mg
Calcium	Milk, cheese, yoghurt, fish, leafy green vegetables, meat	1000-1200mg
Phosphorus	Meat, liver, diary, cereals, nuts	700mg
Magnesium	Green vegetables, whole grains, nuts, seeds	310-420mg
Trace elements		
Iron	Red meat, green vegetables, whole grains, egg yolk, apricot	8-18mg
Copper	Organ meats, nuts, seafood, cocoa, whole grains, Glycyrrhiza glabra	900µg
Zinc	Meat, seafood, oyster, wholegrains, eggs, nuts	8-11mg
Selenium	Organ meats, liver, seafood, eggs, whole grains	55µg
Iodine	Iodized salt, fish, seafood, dairy products	150µg
Chromium	Brewers yeast, nuts, whole grains, mushrooms, black pepper	25-35µg
Fluoride	Drinking water, tea, fish, toohpastes	3-4mg
Manganese	Legumes, whole grains, tea, nuts, apricot, coffee	1.8-2.3mg
Molybdenum	Eggs, organ meat, milk, legumes	45µg

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Conflict of interest

The author declares no conflict of interest.

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