Diseases and Disorders Associated with Vitamin and Protein Deficiencies in Humans

Miguel Angel Palomino-Garibay[1,2]*, Pedro Martín Hernández-Quiroz[1] and María Elena Durán-Lizarraga[1,2]

[1]Academy of Nutrition and Health, College of Sciences and Humanities, Universidad Autónoma de la Ciudad de México, MÉXICO. [2] CETECNA, UACM
*Corresponding author: miguel.palomino@uacm.edu.mx

Abstract

The consumption of a poor diet, lacking some of the essential nutrients for the proper functioning of the body, has serious consequences on health, compromising people's quality of life. Conditions such as malnutrition, delayed growth and development, and chronic fatigue, represent consequences associated with an unbalanced, insufficient, but, above all, incomplete diet. Prolonged maintenance of diets with these characteristics leads to progressive damage to the body and the generation of systemic anomalies, which compromise the functions of organs, devices and systems of the body. The inclusion of vitamins and proteins in the diet is of vital importance. They are essential nutrients so that the body can function optimally. Because the body cannot synthesize them, the incorporation of these nutrients in the diet is decisive. Each one fulfills different functions in the body. Vitamins regulate cellular functioning; have a leading role in growth and development and stimulation of the immune system. While proteins actively participate in the repair and production of cells, the formation of tissues, as well as in metabolic and regulatory processes. Its deficiency can result in alterations in growth and development, the manifestation of chronic diseases, disabling conditions and even cause death, in cases of severe malnutrition.

Keywords: Vitamins, Proteins, Disorders, Diseases, Deficiency

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Introduction

All the processes carried out by the body depend on food. The quality of the diet ingested largely determines the state of health of each person. A healthy diet, which meets the characteristics of being complete, balanced, sufficient, varied and safe, appears as a condition of possibility in the promotion of factors on which both health and quality of life depend (Fanzo & Davis, 2019).

This implies that diets with these characteristics are decisive in avoiding malnutrition, and in a broader sense, play a leading role in health, seen from a holistic perspective. From this position, it is not only about limiting health to the absence of disease, but also comprehensively understanding that all dimensions of life are affected when health is compromised (García-Rodríguez & Rodríguez-León, 2009). Taking care of your diet, through a healthy diet, strengthens growth and development. Likewise, it favors the deployment of all the capacities (physical, mental, intellectual, emotional and social) necessary in daily activities. The health of the body fed in a healthy way not only minimizes the risks of contracting non-communicable diseases, but there is also a better organic response capacity during the course of diseases and infections throughout life (Yeung et al., 2021).

In contrast, poor nutrition compromises both the state of health and the full development of these capacities. The consequences of consuming a diet lacking any of the essential nutrients include a wide range of manifestations. These manifestations can range from mild ones such as fatigue and lack of energy, to alterations that can affect growth and development, as well as generate greater vulnerability to contracting diseases and infections. These deficiencies are also associated with consequences that are more serious. In chronic cases of malnutrition, the damage to health is significant and progressive, leading in the most serious cases to the development of disabling diseases and even causing the death of those who suffer from them. Among these, a greater propensity to suffer from chronic diseases, such as overweight, obesity, type 2 diabetes mellitus, dyslipidemia, fatty liver and metabolic syndrome. Alternatively, complications such as liver and cardiovascular diseases and even deterioration in mental health appear because of poor nutrition (Washi & Ageib, 2010; LaVela et al., 2024).

Vitamins and Proteins in the Diet: Functions in the Body

Diets integrate a combination of foods, whose value lies in the nutrients they provide. A healthy diet seeks to integrate foods capable of satisfying the needs of the body, to perform its metabolic functions as a basis for routine activities. The integration of foods, as well as the nutrients they provide, is the basis for determining the quality of the diet (Tapsell et al., 2016). In general, a healthy diet has the following characteristics: a) Complete, integrating all nutrients, mainly macronutrients (proteins, lipids and carbohydrates) and micronutrients (vitamins and minerals). b) Balanced, the integration of nutrients is in the appropriate proportions. c) Sufficient, the amounts of food (portions) are

adequate to meet needs and maintain a healthy weight. d) Varied, it integrates different types of foods in a combined way (dairy, fruits, vegetables, cereals, legumes, meats and fish). e) Harmless, there is a guarantee that they are free of pathogens, toxins or contaminants. f) Adapted, adjusted to the needs of each person (Sarwar et al., 2015; Carruba et al., 2023).

Proteins and vitamins are important nutritional components in the diet that fulfill important functions in the body. Proteins are large complex molecules, structurally made up of chains of amino acids. The structural arrangement of the amino acids and the length of the polypeptide chain determine the differences between proteins. Because the body is not capable of producing essential amino acids (such as valine, leucine, isoleucine, tryptophan, methionine, threonine, lysine, arginine and phenylalanine), their availability depends on the incorporation of foods that contain them into the diet (Zea et al., 2017). Proteins have been classified as the most diverse and versatile biomolecules due to the functions they fulfill (Zohoori, 2020).

They function as antibodies helping to protect the body, such as immunoglobulins G (IgG). They also act as biocatalysts (such as Phenylalanine hydroxylase), participating in the formation of new molecules. In the messenger function, they transmit signals coordinating biological processes that take place between different types of cells, tissues and organs (such as growth hormone (GH), which is a protein in nature). They carry out their structural function by providing structure and support to cells, which represents an important participation in the formation and repair of both muscle and bone tissues (Gomes et al., 2012; Roefs et al., 2020). Finally, they also fulfill the function of transport and storage, which they perform by binding with molecules located inside the cells or distributed throughout the body (Pasiakos, 2015; Wu, 2016).

Vitamins are essential micronutrients for the body. They fulfill different functions, among which their participation as biocatalysts in cellular chemical reactions, related to energy production and nutrient metabolism, stands out (for example, vitamin B2, catalyzes redox reactions). They are essential for normal growth and development. Likewise, its role stands out in the regulation of the functioning of cellular functions and organs, which includes the establishment of nervous connections that are generated at the cellular level to carry out specific functions (nervous and neuronal network) and the stimulation of the immune system (Maqbool et al., 2017; Barker, 2023).

Vitamins comprise two groups. The fat-soluble ones (A, D, E and K) are those that require the presence of fatty acids or lipids in the daily intake for their absorption. They are stored mainly in the liver, adipose and muscle tissue (Kairnar et al., 2023). Figure 1 shows the functions that vitamin E performs in the body.

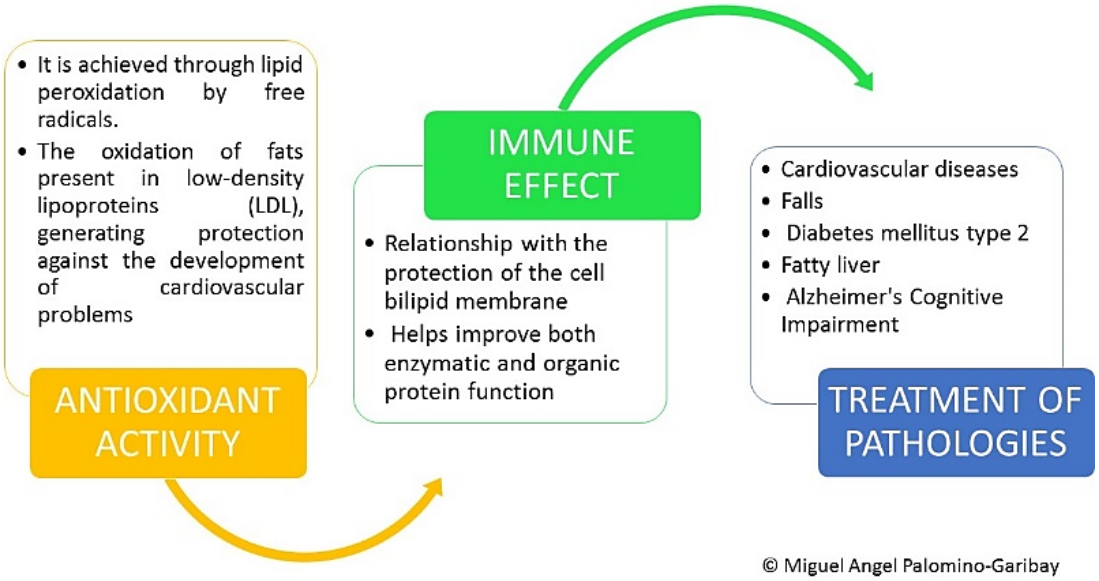

Fig. 1: Functions of vitamin E in the body. Own elaboration.

For their part, water-soluble vitamins (C and B Complex) do not generate organic storage, so they must be consumed regularly to avoid deficiencies and, the appearance of any systemic abnormality (Rafeeq et al., 2020). Table 1 presents information on fat-soluble and water-soluble vitamins.

The absence of vitamins in the body (avitaminosis) generally occurs due to zero or deficient consumption, by not integrating healthy foods into the diet. Nevertheless, this condition can also occur due to the massive loss that occurred during the development of diarrhea episodes, as well as due to prolonged drug consumption. In general, the lack of vitamin consumption for a prolonged period begins to show its damage in the medium term, due to the disorders or health problems associated with this deficiency that usually occur (Maqbool et al., 2017; Rafeeq et al., 2020). Table 2 compiles information on the causes, symptoms and main disorders caused by vitamin deficiency.

The most common diseases associated with this deficiency are Kwashiorkor, characterized by loss of muscle mass, diarrhea, hair thinning and even alopecia, as well as a high susceptibility to developing infections. In Marasmus, protein deficiency causes extreme thinness with high fat reduction and short stature. For its part, protein-calorie malnutrition has a multifactorial origin. The combination of factors such as lack of access to protein generally coincides with episodes of fasting and anorexia. In addition to loss of weight and muscle mass, protein deficiencies cause loss of elasticity in the skin, fluid accumulation in tissues (edsema), hair loss, and weight loss (Gangadharan et al., 2017; Alou et al., 2021).

Table 1: Source, function and recommended daily intake of vitamins

Type of Vitamin	Food Sources	Organic Functions	Recommended Daily Intake (Adults)	Reference
LIPOSOLUBLE				
VITAMIN A (Retinol)	• Egg yolk. • Chicken, cow or sheep liver. • Kidney. • Milk and derivatives. • Oil from fatty fish (such as tuna and sardines). • Orange and yellow fruits, such as peaches, mango and melon. • Also in watercress, sweet potato, carrot, pumpkin, parsley, turnip, spinach and chard.	Helps the formation and maintenance of teeth, bone and soft tissues. Maintenance of healthy mucous membranes and skin.	700 µg (Women) 900 µg (Men) 770 µg (Pregnant women) 1300 µg (Women) lactating	(Lathman, 2002) (Brown & Noelle, 2015) (Rafeeq et al., 2020)
VITAMIN E (Tocopherol)	• Vegetable oil • Nuts • Seeds • Green leafy vegetables • Wheat germ	Antioxidant. It contributes to the formation of red blood cells and the use of vitamin K.	15 mg (22 units of natural or 33 units of synthetic) 19 mg (Women) lactating	(Lathman, 2002) (Rafeeq et al., 2020)
VITAMIN D (Cholecalciferol)	• Egg yolk. • Milk. • Sardine. • Fish oil (cod). • Sun exposure.	Calcium absorption, for the normal development and maintenance of healthy teeth and bones. Helps maintain appropriate blood levels of calcium and phosphorus.	15 µg (600 units) for people aged 1 to 70 years 20 µg (800 units) (People > 70 years old)	(Lathman, 2002) (Rafeeq et al., 2020) (Johnson, 2024)
VITAMIN K (Phylloquinone, Phytomenadione)	• Green leafy vegetables (such as collards, spinach, and cabbage) • Soybean and canola or rapeseed oils	Participation in blood clotting. Important for bone health.	90 µg (Women) 120 µg (Men)	(Lathman, 2002) (Rafeeq et al., 2020) Johnson, 2024)
HYDROSOLUBLE				
VITAMIN C (Ascorbic Acid)	• Citrus • Tomatoes • Potatoes • Broccoli or broccoli • Strawberries • Peppers	Powerful antioxidant that protects cells from oxidative damage. It intervenes in the synthesis of collagen. Improves the absorption of non-heme iron.	75 mg (Women) 90 mg (Men) 85 mg (Women) pregnant 120 mg (Women lactating) 35 mg more for smokers	(Lathman, 2002) (Hemilä, 2017)
VITAMIN B1 (Thiamin)	• Dry yeast • Whole grains • Meat (especially pork and liver) • Enriched cereals • Nuts Legumes • Potatoes	Essential for carbohydrate metabolism and energy production.	1.1 mg (Women) 1.2 mg (Men) 1.4 mg (Women pregnant or lactating)	(Lathman, 2002) (Hanna et al., 2022)
VITAMIN B2 (Riboflavin)	• Milk • Cheese • Liver • Meat • Fish • Eggs • Enriched cereals	Participates in energy metabolism and helps in the production of red blood cells.	1.1 mg (Women) 1.3 mg (Men) 1.4 mg (Women pregnant) 1.6 mg (Women lactating)	(Lathman, 2002) (Hanna et al., 2022)
VITAMIN B3 (Niacin)	• Dry yeast • Liver • Red meat • Poultry Fish • Legumes and products • Whole grain or enriched breads	It participates in the synthesis of fatty acids, energy metabolism and DNA repair.	14 mg (Women) 16 mg (Men) 18 mg (Women) pregnant 17 mg (Women) lactating	(Lathman, 2002) (Hanna et al., 2022)

VITAMIN B5 (Pantothenic acid)	• Liver • Veal or beef • Egg yolk Yeast • Potatoes • Broccoli • Whole grains	Participates in the synthesis of cholesterol, steroid hormones and neurotransmitters.	5 mg (Men and Women) * Food requirements not established 6 mg (Women) pregnant 7 mg (Women) lactating	(Lathman, 2002) (Hanna et al., 2022)
VITAMIN B6 (Pyridoxine)	• Dry yeast • Liver and other viscera • Whole grains • Fish • Legumes	It intervenes in the synthesis of neurotransmitters, the formation of red blood cells and immune function.	1.3 mg (Men) and young women 1.5 mg (Women) over 50 years 1.7 mg (Men) over 50 years of age 1.9 mg (Women) pregnant 2.0 mg (Women) lactating	(Lathman, 2002) (Hanna et al., 2022)
VITAMIN B7 (Biotin)	• Liver • Kidneys • Meats • Eggs • Milk • Fish • Dry yeast • Sweet Potato • Seeds and nuts	Participates in the metabolism of carbohydrates, fats and proteins. Contributes to the health of skin, hair and nails.	30 µg (Men and Women) *Unestablished dietary requirements 35 µg (Lactating women)	(Lathman, 2002) (Hanna et al., 2022)
VITAMIN B9 (Folic Acid)	• Raw green leafy vegetables • Fruits (especially citrus) • Liver and other organ meats Dry yeast and enriched breads • Pastas and cereals (Note: overcooking destroys between 50 and 95% of the folic acid in foods)	Fundamental for DNA synthesis, the formation of red blood cells and the development of the nervous system in fetuses.	400 µg (Men and Women) 600 µg (Pregnant women) 500 µg (Lactating women)	(Lathman, 2002) (Hanna et al., 2022)
VITAMIN B12 (Cyanocobalamin)	• Meat (especially veal or beef, pork • Liver and other viscera) • Eggs • Enriched cereals • Milk • Clams • Oysters • Salmon • Tuna	It participates in the formation of red blood cells, the synthesis of DNA and the maintenance of the nervous system.	2.4 µg (Men and Women) 2.6 µg (Pregnant women) 2.8 µg (Lactating women)	(Lathman, 2002) (Hanna et al., 2022)

Although they are essential nutrients, their integration into the diet must meet the daily recommendations. Both excessive and deficient consumption of vitamins generate disorders in the body. Figure 2 shows the representation of the subsequent events produced by retinol (vitamin A) deficiency.

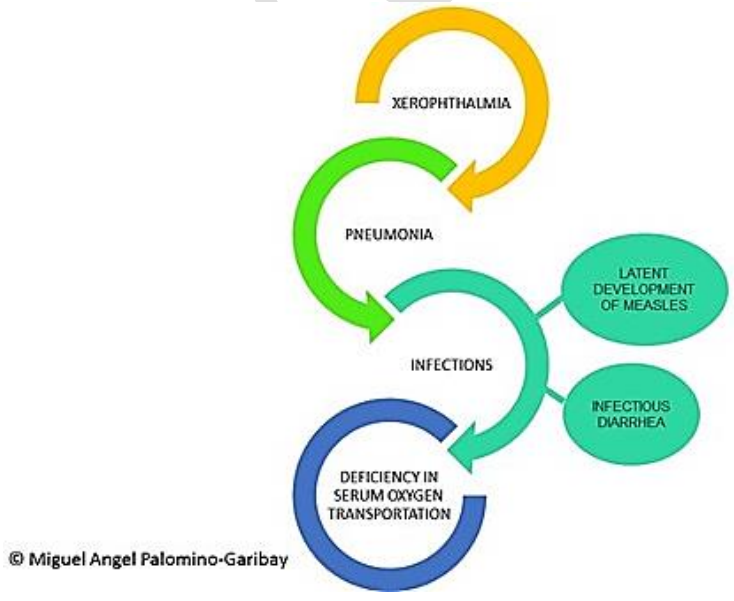

Fig. 2: Disorders and conditions associated with retinol deficiency. Own elaboration.

The absence of vitamins in the body (avitaminosis) generally occurs due to zero or deficient consumption, by not integrating healthy foods into the diet. Nevertheless, this condition can also occur due to the massive loss that occurred during the development of diarrhea episodes, as well as due to prolonged drug consumption. In general, the lack of vitamin consumption for a prolonged period begins to show its damage in the medium term, due to the disorders or health problems associated with this deficiency that usually occur (Maqbool et al., 2017; Rafeeq et al., 2020). Table 2 compiles information on the causes, symptoms and main disorders caused by vitamin deficiency.

Table 2: Pathologies associated with vitamin deficiency

VIT	Cause of deficiency	Deficiency symptoms	Associated pathologies, disorder or disease	Reference
A	Diet deficient in vitamin A for a long time. Low or no intake of foods rich in this vitamin. Presence of celiac disease, cystic fibrosis. Protein-energy malnutrition Pancreatic disorders. Obstruction of bile ducts. Surgery	Night blindness (early symptom), Dry eyes and skin. Higher incidence of ophthalmic and dermal diseases.	Retinal disorders. Blindness in acute and persistent deficiency. Dryness and thickening of the corneas (xerophthalmia), common in children. Dryness of the skin makes it flaky. Hardening of the lining of the lungs, intestine and urinary tract, making their function difficult, leading to the development	(Wiseman et al., 2017) (Johnson, 2024)
E	Diet low in vitamin E. Absorption disorders. Diet with very little fat. Liver and bladder disorders. Pancreatitis and cystic fibrosis. Malabsorption disorder.	Slowed down reflexes. Difficulty walking. Lack of coordination and postural sensitivity. Muscle weakness.	Severe anemia in premature newborns. Dysfunction in reflexes and coordination, locomotor difficulties and muscle weakness. hemolytic anemia	(Johnson, 2024) (Traber, 2024)
D	Diet deficient in vitamin D, combined with lack of sun exposure.	Debilidad, dolor muscular y óseo	In children, rickets. Osteomalacia in women (when the deficiency is severe). Poor absorption of calcium and phosphate Osteoporosis Increased calcium concentration in bones	(Amrein et al., 2020) (Olivo-Torres et al., 2023) (Johnson, 2024)
K	Lack of vitamin K in the diet. Very low-fat diet. Poor absorption Blockage of bile ducts. Cystic fibrosis Drug treatments (anticonvulsants and some antibiotics)	Endodermal bleeding (with bruising), can be fatal in newborns. Stomach hemorrhages with vomiting of blood. Blood in urine and stool.	Vitamin K deficiency in newborns. Brain hemorrhages. Bone weakness. Hemorrhagic disease	(Sankar et al., 2016) (Olivo-Torres et al., 2023) (Johnson, 2024)
B1	Excessive alcohol consumption. Caffeine and alcohol intake. Inadequate consumption of thiamine. Poor and inadequate diet. Malnutrition. Altered intestinal absorption. Diarrhea. Continuous use of diuretics. Advanced kidney disease. Diabetes. Pregnancy and breastfeeding. Drug consumption	Anorexia. Fatigue. Altered reaction to stress. Irritability. Sleep disturbances. Peripheral neuropathy. Cardiac arrhythmia. Memory loss. Cognitive deficiencies. Mental confusion. Apathy. Tremors. Nystagmus in eyes. Increased heart rate. Difficulty breathing. Abdominal and chest pain.	Neurological damage (Wernicke-Korsakoff and Beriberi syndrome) Endocarditis Weakness Chronic fatigue Psychosis Depression Decreased mental dexterity cardiac hypertrophy Congestive heart failure	(Hernando-Requejo, 2018) (Hanna et al., 2022) (Khairnar et al., 2023)

B2	Anorexia nervosa, malabsorption syndrome, prolonged use of barbiturates, pregnancy, dialysis, diarrhea	Fatigue, migraine, stomatitis, cheilitis, glossitis, dermatitis, eye irritation, Cataracts, anemia, personality changes, depression, excessive hair loss,	Skin abnormalities, angular stomatitis, cheilosis,	(Hanna et al., 2022)
B3	Alcohol consumption, use of nicotine patches, low tryptophan intake, high corn diet, carcinoid syndrome, long-term use of isoniazid, Hartnup disease.	Dermatitis, diarrhea, burning, spasms in the extremities	Pellagra, depression, anxiety, memory loss, psychotic symptoms.	(Hanna et al., 2022)
B5	The deficiency is rare unless it occurs in combination with B1 deficiency.	Diarrhea, numbness, burning sensation, dermatitis	Encephalopathy Demyelination Insomnia Behavior changes	(Hanna et al., 2022)
B6	Alcoholism. Poor nutrition (especially a high protein diet). Kidney failure, Malabsorption syndrome Rheumatoid arthritis Use of drugs (contraceptives, corticosteroids, antibiotics). High intake of Vitamin C. Pregnancy and breastfeeding. Kidney difficulties (dialysis or organ transplant). Diseases of the immune system (rheumatroid arthritis, celiac disease, Crohn's disease, ulcerative colitis, intestinal inflammation.	Anemia Nervous system alterations (confusion, concentration disorders, depressed mood and cramps). Weakness of the immune system. Digestive disorders. Liver disorders. Anemia. Seizures. Fatigue. Inflammatory alterations of the skin (dermatitis), the tongue (glossitis) and the oral mucosa. Loss of appetite, vomiting and diarrhea.	Peripheral neuropathy. Schizophrenia Dementia heart disease Strokes Alterations in brain and nerve function. Depression. Loss of appetite weight loss Significant increase in developing colorectal cancer. Degenerative cognitive functions	(Hanna et al., 2022 (Khairnar et al., 2023)
B7	Alcoholism, use of antiepileptics, biotinidase deficiency, pregnancy or lactation.	Dermatitis and tingling sensation in extremities	Depression, lethargy and seizures,	(Hanna et al., 2022

B9	Excessive alcohol consumption. Excessive consumption of cooked vegetables (folate is destroyed by heat). Unhealthy and unbalanced diet. Anemia. Genetic polymorphism. Poor absorption. Poor folate intake. Hemodialysis. Hemolysis. Celiac disease. Crohn's disease. Smokers. Ulcerative colitis. Psoriasis. Pregnant women. Drug consumption (phenytoin, sulfasaline or trimetropim with sulfamethoxazole). Kidney dialysis.	Fatigue, weakness, tiredness, poor concentration. Megaloblastic anemia, Peripheral neuropathy spinal cord injury Cracks in the corners of the mouth.	Behavioral changes, affective disorders, psychosis and dementia	(Thomas-Valdés, 2017) (Hernando-Requejo, 2018) (Hanna et al., 2022) (Khairnar et al., 2023)
B12	Vegan or vegetarian diet. Excessive coffee consumption. Infection with the bacteria Helicobacter pylori. Pernicious anemia, celiac disease, Crohn's disease, poor oral intake, or following a vegan diet. Over 50 years old. Prolonged use of medications (antibiotics, antipsychotics, antiepileptics, anticancer).	Megaloblastic anemia. Peripheral neuropathy. Spinal cord injury. Memory problems. Mental confusion. Fatigue and lack of energy. Mood changes. Muscle weakness and tingling in the extremities. Dizziness and fainting. Balance problems. Chest pain. Difficulty breathing. Numbness. Slow reflexes Decreased nervous system function. Pain in the mouth or tongue.	Behavioral changes Affective disorders Psychosis and dementia Alzheimer's stroke Cardiovascular and cerebrovascular diseases Spinal cord diseases Peripheral neuropathy Anemia Difficulties in the digestive tract, with the risk of developing stomach cancer. Sleep disturbances. Hyperactivity. Irritability Hallucinations and delirium	(Green et al., 2017) (Thomas-Valdés, 2017) (Hernando-Requejo, 2018) (Hanna et al., 2022 (Khairnar et al., 2023)

In the case of proteins, insufficient intake in the diet produces malnutrition and other disorders. Figure 3 illustrates the main pathologies related to deficiency in protein consumption.

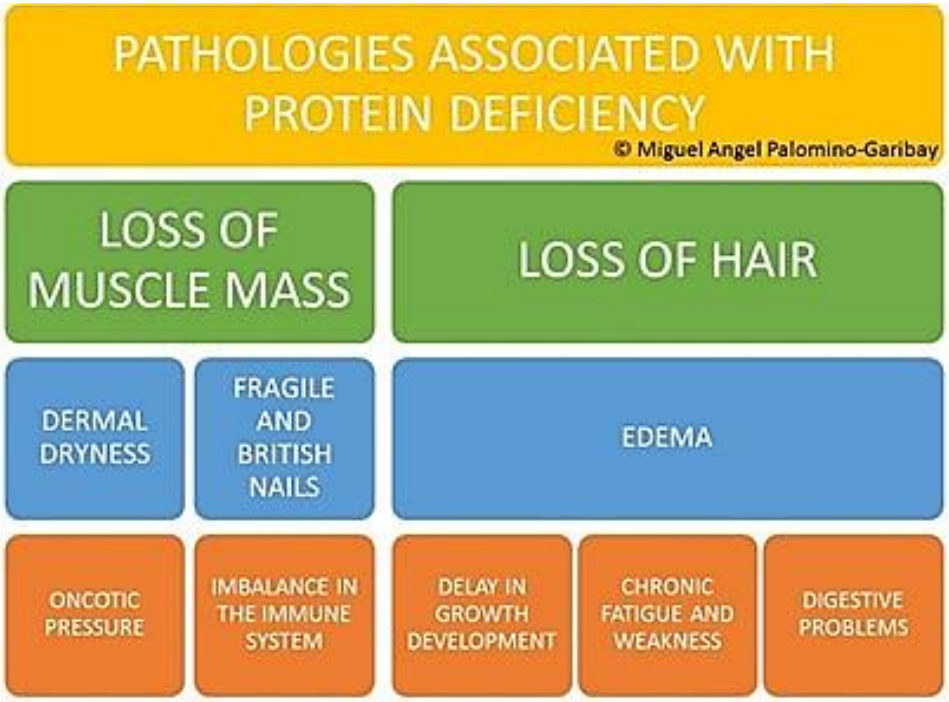

Fig. 3: Pathologies caused by protein deficiency. Own elaboration.

Conclusions

In recent years, the insistence on the importance of having eating habits that include the intake of a healthy diet has two undeniable poles as a reference. Many food options offer the nutrients the body requires. Its consumption allows the body to carry out the metabolic processes essential for life. Likewise, they make it possible to have a quality of life, to attend to daily activities in a satisfactory manner. It is clear that both excesses and deficiencies have an impact on this purpose. The accumulated effects of consuming a diet deficient in some nutrient progressively affect health, due to the appearance of disorders and diseases, many of them chronic. However, the second frontier brings us closer to reality. Many people cannot incorporate the foods included in a healthy diet because they are in a state of vulnerability, linked to food insecurity widely spread throughout the world.

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