



Pediatric nutrology: ten signs of good nutrition

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Abstract

Introduction: Proper nutrition is key to ensuring child health. The “*Manual de Alimentação para crianças entre zero e cinco anos*”, published by the Brazilian Association of Nutrology, is an evidence-based instrument that can be used as a reference by health professionals interested in a comprehensive and detailed evaluation. **Objective:** It was to propose signs indicative of good nutrition in the pediatric age group. **Methods:** Review of the scientific literature in the main national and international databases, aiming to identify the main indicators that point to the adequacy of the food and nutrition processes and their repercussions on health. The data obtained were evaluated by the authors so that it was possible, in a consensual and evidence-based way, to propose ten signs of good nutrition. **Results:** The literature review identified indicators that can be used by health professionals to compose the nutritional assessment during the pediatric consultation. **Conclusions:** Ten signs of good nutrition are presented.

Keywords: Nutritional Status. Nutrition Assessment. Health Status Indicators. Eating. Child.

Introduction

Proper nutrition is crucial for ensuring children's health. However, the process of identifying children at nutritional risk can be complex and requires intense

time, resources, and training. The “*Manual de Alimentação para crianças entre zero e cinco anos*”, published by the Brazilian Association of Nutrology, is an evidence-based instrument that can be used as a reference by health professionals interested in a comprehensive and detailed evaluation [1].

Additionally, the Department of Pediatric Nutrology at ABRAN has created a simplified protocol that can be used by both health professionals and all individuals involved in pediatric care to quickly identify signs of good nutrition and possible deviations from this condition.

Therefore, the objective of this document is precisely to propose ten signs of good nutrition, based on a review of the literature.

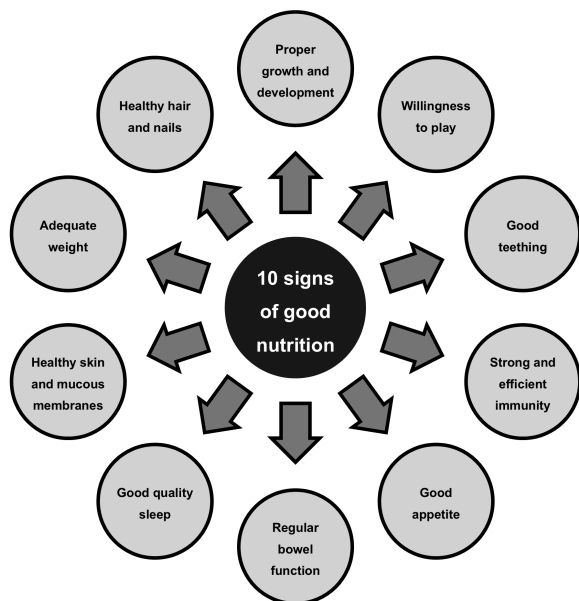
Methodology

Review of the scientific literature in the essential national and international databases, aiming to identify the main indicators that point to the adequacy of food and nutrition processes and their repercussions on health. The data obtained were evaluated by the authors so that it was possible, in a consensual and evidence-based way, to propose the ten signs of good nutrition.

Ten signs of good nutrition

Ten signs of good nutrition are described below according to evidence found in the literature review, with a description of the rationale that justifies each of them. Figure 1 shows these signals graphically.

Figure 1. Ten signs of good nutrition. Source: Own authorship.



1. Proper growth and development

The well-nourished child grows and develops within the expected reference standards.

Growth and development (G&D) depend on several factors. Genetics determines many aspects that are inherited from parents and shaped by epigenetics. The environment contributes to determining how genes will be expressed and includes nutrition, diseases, socioeconomic status, urbanization, physical activity, stress, seasonality, and climate [2]. Although they can be studied separately, they are processes that happen simultaneously and interdependently. In general, it can be considered that all factors that interfere with growth also impact development and vice versa.

From a nutritional point of view, G&D depend on an adequate energy supply and consumption of macro and micronutrients in a complete and balanced way. Proteins have the main "building" function within growth. All organs and tissues need to accumulate proteins, which act as bricks, allowing for progressive gains in mass and structure. At the same time, they also act by composing several other fundamental substances, such as enzymes, hormones, mediators, and neurotransmitters. Finally, they are the sources of essential amino acids, which are necessary for a wide range of metabolic activities, including G&D. The main protein sources are meat, milk, eggs, legumes, and cereals [3].

Carbohydrates fulfill a special energetic function and their metabolization allows the generation of glucose, which is used as a substrate for energy production, essential for G&D to occur in its fullness [3]. Lipids act as an energy reserve that can be

mobilized whenever needed. In addition, they make up the main element of cell membranes, which multiply, generating growth; Membranes also transmit nerve impulses, the basis of neurodevelopment [3]. Long-chain polyunsaturated fatty acids (LC-PUFAS) are the main components of phospholipid membranes, being fundamental for vision and cognition [4].

Vitamin B1 modulates cognitive function and aids energy production by aiding the utilization of glucose by the central nervous system (CNS). Vitamin B9 preserves the brain during its development and helps maintain memory [4]. Vitamin B6 is involved in the synthesis of neurotransmitters. Vitamin B12 also acts in the synthesis of neurotransmitters and improves cognitive function and language. The terminal portion of the cranial nerves is a site of high concentration of vitamin C. Vitamin D acts in the prevention of degenerative diseases [4].

Bone growth depends on calcium and its metabolism is modulated by vitamin D [3]. It also acts on muscle development and on the process of physical growth [5]. Vitamin E protects nerve membranes due to its antioxidant activity and is critical to the full functioning of the CNS [6]. Vitamin A protects the eye structures and acts on vision in low light and is important for immune function and for cell differentiation and multiplication, with impacts on G&D [4,6].

Iron helps in the production of energy in the brain parenchyma via cytochrome oxidase and participates in the synthesis of neurotransmitters and myelin, being considered one of the main nutrients for neurodevelopment [4]. Cell division relies on iron, explaining its role in the growth process [7]. Magnesium acts on the balance of the oxidation-reduction mechanism in the CNS [4] and is part of the bone matrix [3]. It also has effects on learning and memory [8]. Zinc participates in the process of flavor perception and protects against free radicals [4]. It plays a key role in growth [9]. Iodine maintains metabolism through its action on the thyroid and plays a role in the development of intelligence [4,10]. Manganese has an antioxidant role and it also participates in energy production and growth-related processes [3,4].

2. Willingness to play

The well-nourished child receives adequate energy supply and is healthy, showing a good disposition to play.

The willingness to do activities, especially playing, is linked to the child's general well-being. Thus, the main component is the perception of health. Feeling healthy is the basic requirement for being able to think

creatively, move, express oneself, and experience playful fantasies [11]. The immune system is the main responsible for ensuring good health, and, in order for it to act in its fullness, it depends on a series of factors, including a balanced psychosocial situation and adequate nutrition [12,13].

The energy for this process must come from food, through the consumption of especially carbohydrates [3]. And play is also related to neurodevelopment, as cognitive, sensory, creative, and memory processes act together to allow the child to be able to participate in games and play [11]. Nutritional anemia is one of the prevalent conditions among children and leads to significant indisposition and loss of interest in activities that require attention and mobilization, including play [14,15].

3. Good teething

The well-nourished child has strong and healthy teeth, as they receive a sufficient supply of the essential building and regulating nutrients related to teething; They are also less prone to cavities.

Proper dentition has always been, throughout history, a symbol of good health. In fact, it depends on a great complexity of events that must contribute to it to happen completely and properly. The main nutrients for odontogenesis are calcium, phosphate, vitamins A, C, and D, and the proteinenergy balance; deficiency of these elements can cause dental hypoplasia. Vitamin A maintains ectodermal tissues, vitamin D regulates calcium and phosphorus for tooth calcification, and vitamin C is vital for intercellular substances and collagen. Phosphorus strengthens teeth, while lipids and carbohydrates provide energy for odontogenesis [16].

Caries is one of the factors that can lead to tooth decay, and nutrition plays an important role in its prevention and control. The lack of some nutrients, such as vitamins D, E, and K, calcium, iron, and phosphates, is a predisposing factor. Overly acidic foods (especially soda) and excess carbohydrates can also contribute to this process [17].

4. Strong and efficient immunity

The well-nourished child has efficient immunity in protecting against diseases by receiving all the nutrients necessary for the development, maintenance and stimulation of the immune system.

Nutrition is essential for the proper functioning of the immune system, as nutrients regulate and enable defenses. Because it is a highly complex system and needs rapid responses, it needs a large energy intake,

which must be guaranteed by the intake of macronutrients. Regarding micronutrients, many of them participate in immunity. Vitamin A acts in several aspects, such as the integrity of mucosal epithelium, T and B cell mobility in the intestine, microbiota, neutrophil and eosinophil function, number and activity of NK cells, phagocytic and antioxidant ability of macrophages, number and distribution of T cells, Th1/Th2 balance, growth and differentiation of B cells, and action on antibody-mediated immunity [18].

Vitamin B6 acts in the production of interleukin-2, ensuring lymphoid tissue mass, cellmediated immunity, lymphocyte maturation and growth, and antibody response. Vitamin B12 also participates in immunity through NK cell activity, delayed hypersensitivity response (DTH), immune cell number, and T-cytotoxic/T-helper ratio. Folic acid has actions on NK cell cytotoxic activity, antibody and DTH response, cytotoxic T-cell proliferation, immunoglobulin secretion, and T cell proliferation [18].

Vitamin C acts on structure and integrity of the barriers in defense cells in several mechanisms, such as proliferation, functioning, and movement of neutrophils, monocytes, and phagocytes, increasing NK cell activity, increasing phagocytosis activity, and reducing tissue damage [19-24]; promotes differentiation and proliferation of T lymphocytes, especially cytotoxic ones [19,24] and increased antibody production [19].

Vitamin D Has Several Effects on the immune system [25], such as regulation of antimicrobial proteins, maintenance of epithelial barrier function in the gut, kidneys, and cornea. It is essential in the cellular differentiation of monocytes to macrophages, as they migrate from the bloodstream to tissues, and in the movement and phagocytosis activity of macrophages [18,20,24,26]. In macrophages, it increases oxidative activity and superoxide synthesis, reduces the production of inflammatory cytokines, and increases the expression of anti-inflammatory cytokines [26,27]. Its immunomodulatory effect occurs through the inhibition of the proliferation of T lymphocytes and the reduction of the activity of antigen-presenting cells [18,22] and by suppression of excessive antibody production by B lymphocytes [18].

Iron has roles in DTH activity, intracellular pathogen elimination, interleukin-6 production, cellular immunity, NK cell activity, bactericidal activity of lymphocytes, and response to mitogens [18]. Zinc acts on innate immunity as well as adaptive immunity; It helps maintain the integrity of epithelial and mucosal barriers and has a direct nonspecific antiviral role, in addition to reducing oxidative stress that can aggravate infectious processes [28]. In adaptive

immunity, it works by limiting the excessive release of cytokines and increasing the number of regulatory T cells [28]. Zinc-dependent enzymes are involved in the activation of thymulin (thymic hormone) and the balance of the immune system, especially in thymic-dependent lymphocytes (T-cells) [29].

5. Healthy hair and nails

The well-nourished child has healthy hair and nails because it receives all the nutrients necessary for their formation and constant renewal.

Hair and nails are made primarily of protein, especially keratin and collagen, and need a steady supply of vitamins and minerals to grow strong and healthy [30-32]. The lack of protein leads to brittle and stained nails, and thin and brittle hair [31]. For its growth, which is always quite accelerated, nails and hair depend on adequate cell multiplication. In this sense, B vitamins, such as biotin (B7) and folic acid (B9), are essential. Vitamins A and D also affect the hair cycle and need to be present in adequate amounts [33].

Because it is living tissue, they also depend on oxygenation and blood circulation. Iron is crucial for transporting oxygen to hair follicles and nail beds. Iron deficiency is a common cause of hair loss and pale or spoon-shaped nails. Antioxidants such as vitamin E, zinc, and selenium protect nails and hair from oxidative damage. UV radiation harms these tissues, which can be protected by carotenoids present in fruits, vegetables, and legumes. Nails and hair must have a characteristic shine, which is due, especially, to adiposity. Zinc and vitamins A and E contribute to sebum production, as well as acting as antioxidants, protecting against damage and maintaining shine. Finally, infectious processes can lead to damage, and the immunonutrients discussed in item 4 must be guaranteed for nail and hair health [30].

6. Adequate weight

A well-nourished child has a weight within normal limits because they receive adequate energy intake associated with sufficient and balanced macro and micronutrients.

Ever since Federico Gomez found that weight could be used as an indicator of nutritional status, it has become apparent to pediatricians that a well-fed child must have a healthy weight [34]. Negative energy balance, which occurs when the amount of calories ingested is insufficient to meet metabolic demands, leads to low weight [35]. On the other hand, the positive balance promotes an increase in adipose reserves and excessive body mass gain [36].

Additionally, in addition to the energy balance, it is also relevant to consider the balance between macronutrients, in order to promote satisfactory weight gain, which may not occur in situations of imbalance, for example, excessive protein consumption [37].

It is also important to highlight the role of micronutrients that, when ingested in inadequate amounts (more or less), can influence appetite and, consequently, nutrient intake [38].

7. Healthy skin and mucous membranes

A well-nourished child has healthy, flushed, moist skin and mucous membranes without lesions. They are properly renewed and capable of efficient healing.

Specifically in relation to the mucous membranes, deficiencies of proteins, carbohydrates and lipids, as well as vitamins and minerals, can manifest in the oral cavity such as gingivitis and bleeding, recurrent aphthous stomatitis, cheilitis, glossitis and atrophy of the lingual papillae [39]. The skin is the largest organ in the human body. Its three layers have a barrier function and help protect all internal tissues and vital organs from external aggressions. In addition, they represent the main contact surfaces between the organism and the external environment, fulfilling and intermediating highly relevant exchanges. Deficiencies of vitamin A, vitamin C, riboflavin, niacin, pyridoxine, vitamin E, zinc, selenium, and certain essential fatty acids or amino acids lead to skin problems. On the other hand, antioxidants and provitamins protect against free radicals and damage due to the action of ultraviolet rays. A diet rich in fruits and vegetables and other sources of these antioxidants is a key foundation and requirement for healthy skin [40].

Skin and mucous membranes are epithelial tissues with accelerated cell multiplication and intense metabolism, and for this reason, they demand macro and micronutrients in adequate quantity and quality so that they can remain healthy. The healing process, which is often required, makes this process even more expensive [41].

Recent reviews by Giménez et al. and Bjorklund et al. highlighted some nutrients with relevant roles for the skin [42,43]. Vitamin A (retinol) has been shown to absorb UV radiation between 300-350 nm, which imparts a protective role to the skin and stimulates the synthesis of keratinocytes, promotes blood circulation and angiogenesis, regulates exfoliation, achieves a 60% depigmenting effect, protects against acne, and increases skin thickness.

Vitamin C participates in the differentiation of keratinocytes, collagen, and ceramide synthesis. Selenium has a protective effect on the skin against

oxidative stress caused by ultraviolet radiation. Zinc participates in the skin's immune function, modulating the activity of macrophages, neutrophils, and promoting phagocytosis to inhibit inflammatory cytokines, an aspect that allows preventing of inflammatory skin lesions. Copper contributes to collagen maturation, melanin synthesis, and has antimicrobial action [42,43].

Polyunsaturated fatty acids of the ω -3 and ω -6 series are important in the lipid composition of the dermis, in maintaining the necessary balance for an adequate water balance of the skin, in the permeation of active substances, in providing anti-allergic properties, and in promoting cell regeneration. Carotenoids have multiple functions in skin health: modulation of lipogenase activity with anti-inflammatory action, antioxidant and immunomodulatory activity, reduction of lipid peroxidation reactions in the skin, protection of collagen, suppression of damage caused by ultraviolet radiation, protection against damaged skin, improvement of skin hydration, texture and elasticity, reduction of skin hyperpigmentation processes, supply of growth factors necessary for cell regeneration of the epidermis and dermis [42,43].

Polyphenols are characterized by their antioxidant role against the numerous reactive oxygen species to which the skin is exposed, and which lead to lipid oxidation, loss of antioxidant capacity, genesis of inflammatory reactions, collagen breakdown, and skin diseases.

8. Good quality sleep

The well-nourished child falls asleep quickly, sleeps peacefully and for an adequate time and in the morning, wakes up rested and in a good mood.

Sleeping well is an activity that depends on a series of factors of biopsychosocial origin [44]. To wake up well, with disposition and energy, it is essential that the child has been able to sleep correctly, both from the point of view of the number of hours, as well as the quality of sleep [45]. From a strictly nutritional point of view, one of the factors that can lead to difficulty in falling asleep is hunger, so that in order to fall asleep, it is necessary that the child is adequately satiated [46]. When their food needs are not met, the child tends not to be able to sleep [46]. On the other hand, obesity can lead to inadequate sleep due to several factors, including the presence of gastroesophageal reflux and respiratory problems [47].

The essential amino acid tryptophan, present in a healthy diet, is the only precursor of serotonin, both in

the central and peripheral nervous systems, and it, in turn, is a precursor of melatonin, the most important hormone for sleep regulation [48]. An interesting fact, which seems to have a cultural origin, but which can effectively be verified scientifically, is the ability of milk to help induce sleep [49], possibly due to the action of peptides that bind to GABAergic receptors [50,51].

9. Regular bowel function

The well-nourished child has regular bowel function, with painless bowel movements at regular intervals and stools of adequate consistency.

The proper functioning of the intestine depends on several factors, such as water intake, fiber consumption, and microbiota. In general, most children who eat according to the food pyramid should have adequate intestinal transit, without diarrhea or constipation. This is because, by following this guideline, children will have, among other things, satisfactory consumption of soluble and insoluble fiber. Soluble fibers have an important prebiotic effect, promoting a healthy microbiota and contributing to proper colonic functioning. Insoluble fibers have a direct effect on motility, leading to proper intestinal transit. Excess protein in the diet will lead to a microbiota with a putrefactive profile that should culminate in changes in the evacuatory profile. Likewise, an excessively lipid diet can lead to exaggerated rancidification and, when too rich in carbohydrates, fermentation processes can occur beyond what is expected. It is recommended to eat fiber in an amount that can be calculated in a practical way through the equation "age + 5 grams", so that, as an example, a 10-year-old child should ingest 15 grams of fiber daily [52].

10. Good appetite

The well-nourished child has a good appetite, with balanced hunger and satiety and sufficient food intake without being excessive.

Appetite is influenced by several factors. First, it is important to remember that most diseases lead to the production of cytokines with an anorectic effect [53]. Therefore, one of the basic premises for the child to be hungry is to be healthy. However, from a nutritional point of view, several situations can occur with low appetite. Paradoxically, one of these conditions is precisely malnutrition, which, when it presents itself in the severe form, progresses with anorexia [54].

Many micronutrients also influence, directly or indirectly, appetite. Deficiencies of zinc, copper, and nickel lead to a reduction in taste perception and, by not perceiving tastes and flavors, the child may lose

interest in eating [55]. Specifically in relation to zinc, the gustine protein, which is secreted by the parotid gland and has its synthesis modulated by zinc [56], participates in the synergistic relationship between salivary secretion and stimulation of the taste buds [57].

Zinc deficiency can modify food intake not only by decreasing the acuity of taste [9], but also because it interferes with the central control of appetite due to changes in the structure and function of the cell membrane, which result in a decrease in the response of neurotransmitter receptors such as catecholamines, serotonin, and opiates [58]. Anemia, on the other hand, either due to lack of iron or other micronutrients, classically progresses with anorexia [8,59,60].

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