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Assessing Dietary Supplements, Nutritional Deficiencies, and the Potential of Personalized Nutrition

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Abstract:

The COVID-19 pandemic has heightened public awareness of health, leading to a surge in the consumption of dietary supplements, particularly vitamins and minerals. These micronutrients are vital for numerous physiological processes and overall health maintenance. However, the rapid expansion of the health product market has also resulted in the proliferation of substandard items and the risk of misuse or overconsumption. This study analyzes the ingredients in various health products and assesses the nutritional deficiencies prevalent in local populations. It emphasizes the importance of balanced nutrition while cautioning against the excessive intake of certain supplements. The research also explores the potential of personalized nutrition, driven by advances in genomics and biotechnology, to provide tailored supplement recommendations. Additionally, the study highlights the need for stricter regulations and improved quality control in the health product industry to ensure consumer safety and confidence. By offering insights into the nutritional needs of individuals, this study aims to guide informed and responsible supplement use.

Keywords: Dietary supplements; nutritional deficiencies; personalized nutrition.

1. Introduction

Following the COVID-19 pandemic, people have become increasingly health-conscious and are purchasing more health products. These products are typically used to supplement trace elements not regularly consumed in daily diets, such as vitamins and essential minerals. Trace elements, including vitamins and minerals, are essential micronutrients that play pivotal roles in maintaining human health and well-being. These elements, although required in small quantities, are crucial for various physiological processes, enzymatic reactions, and the overall functioning of biomolecules within the body.

According to the National Health Center for Health Statistics: In the U.S., 57.6% of adults aged 20 and over reported using dietary supplements in the past 30 days, with female (63.8%) outpacing male (50.8%) in the intake of health products. Usage rates and age rised together for both sexes, peaking at 80.2% among women aged 60 and over. As people age, they tend to use more dietary supplements, with the use of two, three, or more supplements becoming more common, and the percentage of adults not using any supplements decreasing. The most frequently used supplements across all divisions of age are vitamins and mineral supplements, included vitamin D and omega-3 fatty acids. Starts from 2007 and 2008 to 2017 and 2018, the tendency and commonality of usage of health products rose among U.S. adults in every age group [1].

Nevertheless, as the health care product market expands, numerous substandard products have emerged. The general public often lacks the specialized knowledge to distinguish between necessary and unnecessary products, leading to purchases of unneeded supplements or excessive intake of trace elements.

This study will analyze the ingredients and trace elements in various health products, provide an overview of the substances most commonly found in these products, and assess the nutritional deficiencies of local populations based on their diets. Additionally, the study will compare different health products available on the market, evaluating the effects of various trace elements on biological molecules and their mechanisms in the human body to identify potential safety hazards.

This study aims to deepen people's understanding of their nutritional requirements and educate the public on distinguishing between various health products. Another goal is to highlight the importance of consuming adequate trace elements and promoting balanced nutrition. Moreover, it

will help the public better understand which health products they truly need and to enhance their awareness of these products as global attention to health issues increases.

2. Biological Functions of Major Vitamins

2.1 Vitamin A

Vitamin A is crucial for human vision, particularly in enabling the eye to perceive a wide range of light. It is essential for the production of specific pigments necessary for the retina's proper functioning [2]. Without adequate vitamin A, these pigments are not produced, resulting in night blindness [2]. Additionally, vitamin A is vital for maintaining other eye structures, such as the cornea, as it helps in producing sufficient moisture to keep the eyes lubricated. Beyond its role in vision, vitamin A significantly impacts the immune system. It has been recently noted for its influence on immune responses, with observational studies linking it to various health conditions, including infections, inflammatory and allergic diseases, and some cancers, though further research is required to solidify these connections [3]. Research in vivo and in vitro has shown that vitamin A, through the formation of the retinoic acid/retinoic acid receptor complex, is vital for both innate and adaptive immune cell responses. Furthermore, vitamin A is necessary for mucus production and the development and maturation of epithelial cells, highlighting its dual role in immune regulation and epithelial health [4]. Primary sources of vitamin A include fish oils, milk, and eggs, with plant-based sources like carrots, sweet potatoes, spinach, kale, and other leafy greens. A deficiency in vitamin A can cause night blindness, xerophthalmia (dryness of the conjunctiva and cornea), increased vulnerability to infections, and skin problems [5]. An excess of vitamin A can result in Hypervitaminosis A, characterized by nausea, headaches, dizziness, and potential liver damage.

2.2 Vitamin C

Vitamin C, or L-ascorbic acid, is an essential water-soluble vitamin found naturally in certain foods, added to others, and available as a dietary supplement. It is renowned for its antioxidant properties, which allow it to neutralize free radicals directly by interacting with aqueous peroxyl radicals, and indirectly by regenerating the antioxidant capacity of vitamin E, a fat-soluble vitamin [5]. These actions collectively help to protect cellular membranes from lipid peroxidation, preserving both the outer and inner cell structures, and also mitigating the damage to nuclear material from free radicals.

One of the key benefits of vitamin C is its role in skin health, where it significantly stimulates collagen production. Collagen types I and III, crucial for maintaining skin structure, decrease with age, and vitamin C is vital for promoting their synthesis, despite its limited ability to penetrate the epidermis' stratum corneum barrier effectively [6]. Additionally, vitamin C aids in the absorption of iron by creating an acidic environment within the stomach, which prevents the oxidation of ferrous iron to ferric iron, thereby enhancing its bioavailability [7].

Key dietary sources of vitamin C include citrus fruits, strawberries, bell peppers, broccoli, and Brussels sprouts. A deficiency in vitamin C can lead to scurvy, characterized by symptoms such as weakness, anemia, gum disease, and skin issues, due to its essential role in collagen synthesis, a major component of connective tissue. Although vitamin C is generally safe with low toxicity, excessive intake may cause gastrointestinal discomfort and increase the risk of kidney stones [8].

2.3 Vitamin D

Vitamin D, comprising vitamin D2 (ergocalciferol) and vitamin D3 (cholecalciferol), plays a crucial role in calcium absorption [9]. Ergocalciferol is obtained from irradiated fungi or yeast, whereas cholecalciferol is synthesized in the skin through UVB radiation exposure or naturally present in fatty fish like salmon and mackerel [10]. Both forms of vitamin D are used to fortify foods, but only cholecalciferol can be endogenously produced when UVB rays (290-315 nm) convert 7-dehydrocholesterol in the skin into previtamin D3, which then transforms into vitamin D3 [11]. Factors such as skin color, age, sunscreen use, and time of day, season, and latitude affect this synthesis process.

Vitamin D is vital for regulating immune responses, both innate and adaptive. It interacts with vitamin D receptors on innate immune cells, essential for maintaining immune health. By binding to receptors on cells like neutrophils, macrophages, and natural killer cells, vitamin D induces the production of antiviral peptides, such as cathelicidins and defensins, which have antimicrobial and immune-modulating properties. These peptides act as antiviral agents within the innate immune system, enhancing its response. Additionally, vitamin D activates immune cells to combat infections and suppresses excessive inflammation [12].

Sunlight exposure, fatty fish, fortified dairy products, and egg yolks are the primary sources of vitamin D. A defi-

ciency in vitamin D can lead to rickets in children, osteomalacia and osteoporosis in adults, and a higher risk of infections and chronic diseases. Conversely, an overdose of vitamin D can cause hypercalcemia, leading to vascular and tissue calcification and kidney damage [13].

3. The Role of Vitamin Supplements in Modern Diets

When discussing vitamin supplements and dietary products, it's crucial to recognize their potential benefits and risks. Although vitamin supplements can help correct deficiencies, their use should be guided by healthcare professionals to avoid adverse effects. Overconsumption of fat-soluble vitamins like A, D, E, and K can lead to toxicity.

Adults across all age groups commonly use dietary supplements such as multivitamin-minerals, vitamin D, and omega-3 fatty acids. Multivitamin-minerals are taken by 24.0% of individuals aged 20–39, 29.8% of those aged 40–59, and 39.4% of those 60 and over. Vitamin D usage is 6.7% for ages 20–39, 17.4% for 40–59, and 36.9% for 60 and over. Omega-3 fatty acids are used by 5.4% of those aged 20–39, 12.5% of those aged 40–59, and 21.8% of those 60 and over. The fourth most common supplements differ by age: vitamin C for ages 20–39, botanicals for ages 40–59, and calcium for those 60 and over. The fifth most common are botanicals for ages 20–39, calcium for ages 40–59, and vitamin B12 for those 60 and over [14].

Understanding the function of vitamin supplements in addressing deficiencies is essential, but their interactions and effects are complex. For instance, antioxidants like vitamin C can neutralize harmful free radicals, which, if unchecked, can damage DNA and potentially lead to cancer. However, free radicals also play a role in the immune system's ability to fight infections. High doses of antioxidants may interfere with this process, possibly leading to increased infections. Vitamin A has been associated with a higher incidence of lung cancer in smokers, and excessive zinc intake can impair immune function. Long-term excess intake of manganese has been linked to muscle and nerve disease in the elderly, and excess niacin can cause cell damage [15].

Complications arise when multiple supplements are taken together. Different minerals compete for absorption; for example, high calcium intake can inhibit iron absorption, and excessive iron can interfere with zinc absorption. High doses of vitamin C can reduce copper levels. Despite manufacturers' claims of optimal ratios, achieving the right balance is challenging.

Essential nutrients must be balanced for the body's complex processes. When taken as supplements, vitamins are introduced at levels unattainable through diet alone, often in isolation. In contrast, vitamins from foods come with various supporting compounds, enhancing their effectiveness. Simply taking a vitamin pill does not compensate for a lack of energy or overall wellness; it's the synergy of multiple compounds in foods that provides protection. Additionally, vitamin and mineral supplements can interfere with prescription medications, sometimes with severe consequences, such as negating the effects of anticonvulsant drugs used for epilepsy [16].

4. Conclusion

In conclusion, the increasing health consciousness following the COVID-19 pandemic has led to a significant rise in the use of dietary supplements, particularly vitamins and minerals, which are essential for maintaining overall health. While these micronutrients play crucial roles in various physiological processes and support immune function, the expanding market for health products also raises concerns about the proliferation of substandard items and the potential for misuse or overconsumption. This study aims to analyze the ingredients in various health products and assess the nutritional deficiencies prevalent in local populations, ultimately encouraging a better understanding of individual nutritional needs. It highlights the importance of balanced nutrition while emphasizing the risks associated with excessive intake of certain vitamins and minerals. Consumers must be informed and cautious, seeking guidance from healthcare professionals to avoid potential adverse effects on their health.

There are future prospects about health products. Every person has unique gene for the rate of absorbing and digesting the vitamins and other trace elements. Advances in genomics and biotechnology may enable personalized nutrition, allowing individuals to receive tailored recommendations for vitamin and mineral supplementation based on their genetic makeup, dietary habits, and health status. This could enhance the effectiveness of dietary supplements and reduce the risk of overconsumption. Moreover, as awareness of the health benefits of vitamins and minerals grows, there will likely be increased investment in research and development. This could lead to better understanding of the mechanisms through which these nutrients work and the development of new formulations that maximize their benefits. Finally, with the growing market and increasing concerns about quality and safety, there may be a push for stricter regulations governing health products. Improved quality control measures and

clearer labeling standards could help consumers make more informed choices, fostering confidence in dietary supplements

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