The Net Micronutrient Balance Value Concept: Revisiting Orthomolecular Nutrition

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ABSTRACT

Nutrition research has been pivotal in establishing causality between dietary (nutrient) intake and health outcome measures. Nutrition is also relevant in the determination of dietary requirements and levels of supplementation to achieve specific physiological outcomes. Careful nutritional research led to the conclusion that food products considered the same or equivalent may have significant differences due to soil quality, agricultural methods, contaminants, food processing, additives, and cooking methods. We propose the concept of the net micronutrient balance value (NMBV), which refers to the actual micronutrient content of the food product minus the portion not absorbed and the amount depleted in metabolic processes due to additives, contaminants, medication, and faulty metabolism. Diet quality over time determines physical growth, mental development, and numerous health risks, including cardiovascular disease, cancer, diabetes, and many other chronic conditions. Therefore, research in nutrition needs to identify and consider the specific variables that determine NMBV to provide better uniformity in nutrition research and produce more significant and meaningful findings.

Keywords: Nutrient depletion; Processed food; Refined food; Organic food; Pesticides; Microbiome

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INTRODUCTION

Nutrition, diet, and physical activity play important roles in promoting health and preventing and treating disease. Proper nutrition offers one of the most effective and least costly ways to decrease the burden of many diseases and their associated risk factors. The importance of nutrition as an integral part of the solution to many societal, environmental, medical, and economic challenges facing the world has been neglected for years. It may have just started to be meaningfully appreciated. Cultural influences, societal convenience, marketing, and other factors have influenced eating habits for decades. The detrimental impact of poor nutrition on the health and wellbeing of individuals, healthcare systems, and the economy is substantial.

Nutrition refers to the integrated processes by which cells, tissues, organs, and the whole body acquire the energy and nutrients through the diet needed for normal structure and function and the capacity to transform substrates and use cofactors necessary for metabolism.

The science of human nutrition considers the nature and interaction of two internal and external systems. The external system is composed of the food ecosystem. It involves complicated factors determining the human ability to source a complete diet from the wider environment that provides adequate energy and nutrients. It encompasses the world created by the family and community, incorporating complex social systems and interactions that influence lifestyle choices. The internal system is the body's regulated biochemical, physiological, and metabolic processes that create an internal environment where cells, tissues, and organs can maintain their structure and function to ensure ongoing optimal health. Health is enabled and protected when the two systems are balanced and harmonious.

Defining healthy or optimal nutrition is a very complex task. Nutritional requirements (both maximum and minimum) may vary substantially according to age, sex, body weight, genotype, level of activity, physiological status (growth, pregnancy, and lactation), and the presence or absence of disease. Good nutrition is not simply met by the absence of nutrient deficiencies but by defining the appropriate intake to sustain growth and development across the life cycle, including immune development and function.

Nutritional status has been shown to play a key role in important physiological processes such as mucosal integrity and barrier function (e.g., respiratory and gastrointestinal), cognitive function, and immune response. Nutritional status can also affect resilience, susceptibility to disease, and response to therapy. It can also affect the body's response to medication. It is not surprising, therefore, that poor nutritional status, caused by either an unhealthy diet or malabsorption of nutrients, is a major risk factor for many chronic diseases.

Poor diet is a leading cause of ill health worldwide. Poor nutrition (under- and overnutrition) is not confined to developing or transitioning economies but also affects high-income, industrialized countries (the hidden hunger concept). Providing adequate nutritional support is vital for those with acute or long-term health conditions, whether during treatment, recovery, or palliative care.

Nutrition researchers are trained to examine the complex interplay between foods eaten and health and disease status in individuals or populations. Given the huge impact of diet on a person's health and the fact that everyone eats, it is no surprise that studies in human nutrition are crucially important. There are four main types of research studies about nutrition: animal or laboratory, case-control, cohort, and randomized. Nutrition research is needed to establish the required nutritional needs that best support survival, growth, and development in subpopulations such as chronically diseased patients, children, and aging adults.

To fully appreciate the many challenges surrounding nutrition and nutrition research, it is important to understand some key elements involved, including research designs, the complexity of the food environment, and approaches to collecting and analyzing dietary data.

NUTRITION RESEARCH CHALLENGES

For nutrition research and its associated disciplines, ethical considerations are often complicated by factors that range from overly holistic study designs to inextricable links with marketing. Consequently, constant vigilance is needed to assess and deal with apparent conflicts of interest. Also, there are few scientific disciplines that are more defined by cultural, religious, or political codifications than nutrition. Therefore, nutrition research questions are often extremely multifaceted and require dealing with complex variables.

Foods and food products are available in different varieties, brands, and flavors. There are many options for the same type of food, yet the ingredients in each option may differ in ways that matter greatly to nutrition and nutrition research. How food is cooked can change its nutrient profile. People vary in many ways, including by sex, race/ethnicity, BMI, economic status, metabolic rate, food preferences, exercise patterns, and fitness levels. All these different variables could affect what study participants eat, how they metabolize what they eat, and how much they remember about what they eat. Food and nutrition databases have many limitations.

Nutrition and nutrition research should focus on the following high-priority areas: (1) variability in individual responses to diet and foods; (2) healthy growth, development, and reproduction; (3) health maintenance; (4) medical management; (5) nutrition-related behaviors; (6) food supply/environment; and (7) nutritional supplementation and diseases. Findings from these areas will help elucidate strategies that can be applied toward the prevention and treatment of both infectious and non-communicable diseases, including cardiovascular disease, diabetes, and cancer.[1]

FOOD QUALITY ISSUES

Diet Quality Indices (DQIs) are evaluation tools used to quantify the overall quality of an individual's diet by scoring food and/or nutrient intakes, and sometimes lifestyle factors, according to how closely they align with dietary guidelines.[2] There is a variety of DQIs that employ a variety of scoring matrices. Some use food frequency, quantity, or food group consumption, while others use nutrient intake. The quantity, quality, frequency, and specific timing of the ingestion of nutrients are all important considerations, as any variable by itself can make a difference. Quantity, which refers to the total amount of macronutrients in the diet and its associated calories, is the most obvious factor to measure.

Evaluating food quality criteria is much more complex. Many quality determinants are involved when investigating a particular food or food product, macronutrient, or food group source such as fruits, vegetables, grains, proteins, and dairy. These determinants include wholeness, ripeness, freshness, additives, pesticides, and herbicides. Crop origin is particularly important for several reasons, including soil quality, agricultural methods, crop processing, packaging, and distribution. Soil quality is known to determine the nutritional content of the crop.[3,4] Decades of bad farming practices produced historical declines in crop micronutrient density. In fact, between 1950 and 1999, there was a sustained decline in levels of six nutrients (protein, Ca, P, Fe, riboflavin, and ascorbic acid) in at least 43 foods.[5] Several studies have been published that help explain and delineate better practices.[2,6–8]

PROCESSING, REFINING, AND THE NUTRIENT SUBTRACTION EFFECT

Food refining processes that cause the most nutrient loss expose foods to high heat, light, and/or oxidative conditions.[9] Processing is commonly used to improve taste and shelf stability and to simplify and shorten food preparation time. However, processing can also increase the glycemic index and reduce fiber, vitamin, mineral, and phytochemical content.[10]

Food additives are prevalent in packaged processed foods to increase shelf life and improve appearance or flavor. In fact, over 10,000 substances are approved as additives to food products in the

United States.[11] Some of these additives give rise to health concerns, especially for vulnerable populations like children. Additives include colorings, flavorings, and chemicals deliberately added to food during processing (direct food additives). In addition, indirect additives are substances in food contact materials that contaminate food as part of the packaging or manufacturing process, such as adhesives, dyes, coatings, paper, paperboard, plastics, and other polymers.[11] It has been stated by the Council of Environmental Health that the designation "generally recognized as safe" (GRAS) is insufficient to ensure the safety of food additives. It also does not contain sufficient protection against conflicts of interest. Furthermore, the FDA needs more authority to acquire data on all chemicals on the market or independently verify their safety for human health.[11]

In addition, for nearly 80% of chemical additives intentionally added to food, it has been reported that the FDA's database lacks the information necessary to predict the amount people can safely consume. Moreover, despite FDA requirements, 93% of additives lack reproductive or developmental toxicity data.[12]

These additives may have metabolic, enzymatic, or other biological consequences and thus must be considered when evaluating a food product. Many are already associated with health risks. Trans fats used for texture have been shown to increase the risk of heart disease, type 2 diabetes, and stroke.[13] Nitrates and nitrites used in processed meats can lead to certain cancers and other significant health problems.[14] High fructose corn syrup (HFCS) is a very common and cheap sweetener, but research indicates it can lead to obesity and type 2 diabetes.[15] Recent studies show that fructose-induced uric acid production causes mitochondrial oxidative stress that promotes fat accumulation independent of excessive caloric intake.[16] It has been proposed that fructose-mediated generation of uric acid may have a causal role in diabetes and obesity.[17] Artificial sweeteners have been shown to induce glucose intolerance by altering the gastrointestinal microbiota.[18] In addition, aspartame is an artificial sweetener commonly found in sugar-free sodas, and many other products. Several studies have shown that aspartame can cause headaches in vulnerable individuals and may cause symptoms of depression or anxiety.[19,20]

THE IMPACT OF PESTICIDES

Pesticides and herbicides are very common in current commercial farming practices. Testing conducted by the environmental working group (EWG) revealed that more than 90% of samples of strawberries, apples, cherries, spinach, nectarines, and leafy greens tested positive for residues of two or more pesticides.[21] Also, glyphosate, a herbicide linked to many diseases, is widely used in the agricultural industry. The EWG found glyphosate in over 95% of popular oat-based food samples. The report included 12 wheat-based products, five dried pasta samples, and seven cereal samples.[22]

These toxic substances present in food travel through the gastrointestinal tract, where they damage the microbiome,[23] possibly including bacteria necessary for the synthesis of vitamins such as vitamin K and B group vitamins, including biotin, cobalamin, folates, nicotinic acid, pantothenic acid, pyridoxine, riboflavin, and thiamine.[24] In addition, these toxic compounds enter the systemic circulation and are distributed to various tissues. Pesticides from food undergo phase I and II enzyme detoxification,[25] which requires micronutrients such as B complex vitamins, vitamin C, vitamin E, and glutathione as cofactors.

Increased use of these pollutants contaminates food and, when chronically consumed, can harm health. An animal study of long-term exposure to two pesticides demonstrated a subsequent increase in mitochondrial malondialdehyde, swelling, dysfunction, and a decrease in glutathione.[26] Herbicides and pesticides have been associated with increased oxidative stress, inflammation, and depletion of glutathione and antioxidants.[27,28] Pesticides in food can cause an excess of reactive oxygen species (ROS) and subsequent depletion of antioxidants, micronutrients, and glutathione, which can result in altered net balance of nutrients.

THE MICROBIOTA AND MICROBIOME

The human microbiota refers to the vast array of commensal microorganisms that live mostly in

the intestines, with some residing in the oral and vaginal mucosa, skin, and other tissues. These microorganisms include bacteria, viruses, and fungi. The term microbiome denotes the set of genomes of all these microorganisms. Microbes in the human body are nourished by food and molecules in their environment, and they produce metabolites according to their metabolism and genome, which profoundly impact human metabolism. This influence can be broadly categorized in different areas, such as human nutrition, physiology, immunity, behavior, and disease.[29] Research shows an important connection between the gut microbiome and stress response, inflammation, depression, and anxiety.[30]

Nutrient-dense foods are high in micronutrients and relatively low in calories.[31] Consuming fast food and processed food, which are low in fiber and contain additives such as sweeteners, antibiotics, persistent organic pollutants, and pesticides, provides calories from added sugars and refined oils with minimal micronutrients. Low nutrient-dense processed foods create an environment that is hostile to microbiota health.[18,23] They are also associated with the increased incidence of chronic disease seen over the past several decades. Therefore, any comprehensive nutritional analysis should also examine the influence of diet on the human microbiome.

NET MICRONUTRIENT BALANCE VALUE (NMBV)

The NMBV is the sum of all micronutrients present in a food minus those depleted (micronutrient depleting potential). The micronutrient depleting potential accounts for the depleting effect of antinutrients such as phytates, tannins, lectins, and oxalates, as well as the method of consumption (raw, sprouted, fermented, cooked). Antinutrients in vegetables, whole grains, legumes, and nuts are mostly a concern when a diet consists of a significant proportion of uncooked plant foods.[32–34] The NMBV can be reduced by natural antinutrients, refining processes, drug: nutrient interactions, and contaminants such as pesticides, herbicides, and medication. In contrast, organic produce is more nutritious because it contains only naturally occurring antinutrients, not agricultural contaminants.

The animal's diet will determine the nutritional profile of animal-based food products such as meat, milk, and eggs. Grass-fed, free-range animals, wild-caught fish, and seafood contain beneficial lipids that can significantly positively affect physiology over time.

The Net Micronutrient Balance Value concept proposes to distill a more accurate evaluation of nutrients by considering components that enhance the nutritional/physiologic benefit (enhanced value factors) and decrease the nutritional/physiologic benefit (subtraction factors) (Figure 1). Enhanced value or subtraction factors can relate to the food itself, for example, soil quality, where it was produced, genetic modification, pesticide use, how crops/animals were nourished, and level of processing. In addition, enhanced value or subtraction factors about the human organism include health status, genomics, age, and microbiome profile.

FOOD EXAMPLES

Eggs

Pastured (free-range) eggs are rich in vitamins A and E, as well as omega-3 fatty acids.[35–37] In one study, the highest content was found in eggs from organic farming.[38] Hens that get to spend time in the sun lay eggs that contain significantly more vitamin D. Omega-3 eggs have about five times as much omega-3 and 39% less arachidonic acid than a regular egg. In other words, these eggs contain significantly more anti-inflammatory and less inflammatory fats, and significantly more vitamin D.[39]

Meat

Studies have shown that pasturing chicken improves the nutritional value of the meat in terms of fatty acid proportions (polyunsaturated fatty acid [PUFA] n-3 and the ratio between n-6 and n-3 PUFA).[40–42] Red meat from ruminants such as cows, sheep, and goats is an important dietary source in developed countries and high socio-economic groups in developing countries. The diet of ruminants significantly influences the concentration of

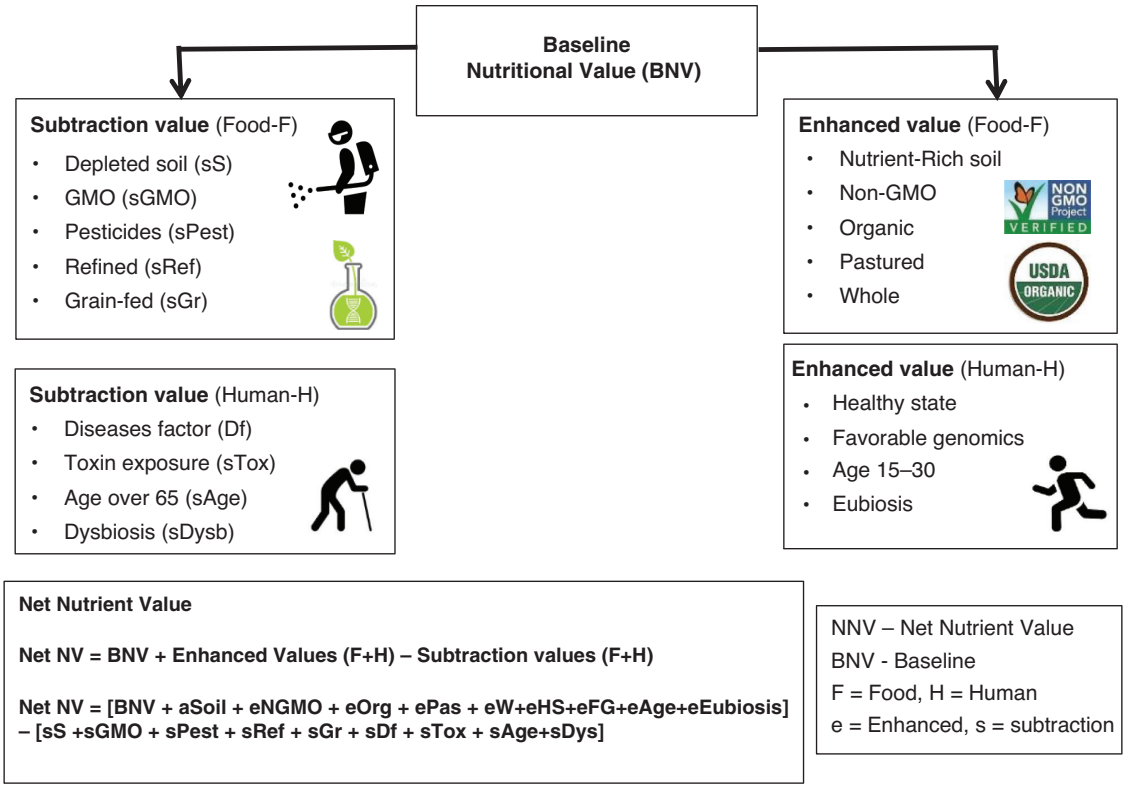

Figure 1: Net micronutrient balance value (NMBV) diagram.

omega-3 fatty acids in their meat. Meat from grass-fed or forage ruminants has a greater concentration of omega-3 fatty acids than grain-fed counterparts.[43] An accurate nutritional assessment requires consideration of the meat's nutritional value based on the animal's diet.

AGE-RELATED DIGESTIVE ENZYME PRODUCTION

With aging, digestion is slowed down[44] as pancreatic exocrine digestive secretions decrease after the third decade of age.[45,46] The reduction of pancreatic digestive enzymes may eventually result in decreased nutrient absorption, insufficiencies, and deficiencies with subsequent immune weakening, especially in old people or those with genetic or metabolic vulnerabilities.[47]

Supplementation of digestive enzymes that include proteases, amylases, lipases, pancreatin, cellulase, and lipase, in addition to improving digestion of foods, can decrease post-surgery recovery time and, in some cases, may act as an adjuvant in cancer treatment.[48,49]

Age and pancreatic enzyme function need to be considered in nutrition research as they may affect digestion and nutrient availability. The use of digestive dietary supplementation might reduce age-dependent pancreatic enzyme deficiencies.

RESEARCH IN DIET, CHRONIC DISEASE, AND MORTALITY

A prospective cohort study of 63,805 participants within the Women's Health Initiative Observational Study who had better diet quality (as assessed by the Healthy Eating Index [HEI], the Alternative Healthy Eating Index [AHEI], the alternate Mediterranean Diet [aMED], and Dietary Approaches to Stop Hypertension [DASH] scores) found a statistically significant 18%–26% lower all-cause and cardiovascular disease (CVD) mortality

risk in this population. In addition, specific diet scores were also associated with a statistically significant 20%–23% lower risk of cancer mortality.[50] Another study examined the relationships between four indices – HEI-2010, AHEI-2010, aMED, and DASH – and all-cause, CVD, and cancer mortality in the NIH-AARP Diet and Health Study (*N*=492,823). Data from a 124-item food-frequency questionnaire were used to calculate scores. Higher index scores were associated with a 12%–28% decreased risk of all-cause, CVD, and cancer mortality.[51]

CONCLUSION

Everyone must eat, making diet one of the most common factors influencing health and disease outcomes. Nutrition research is complicated by numerous factors inherent in this area of inquiry. More accurate and complete reporting in the lay press and even peer-reviewed publications can further complicate things and create confusion among the public. Nevertheless, nutrition research has enormous potential to clarify concepts necessary for preventing and improving disease management and overall health. With its myriad health implications, nutrition is an exciting, challenging, and ever-evolving area of research. The production and consumption of processed food have increased over the last decades,[52] coinciding with consistently rising trends of obesity and chronic disease.[53]

Careful nutritional research must recognize that similar food products that are considered to have the same nutritional value may have significant differences in terms of their NMBV. Variables that affect NMBV include soil quality, agricultural methods, contaminants, food processing, additives, and cooking methods. These factors can enhance or decrease the micronutrient value. Identifying and considering the effects of these and other specific variables will help produce more uniformity and better insight into the role of nutrition in health and disease.

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