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Editorial

Nutrigenomics: Understanding the Connection Between Nutrition and Genetics

I Putu Gede Windhu Saputra

Siloam Hospitals Denpasar, Bali, Indonesia
Correspondence: windhusaputra@gmail.com

ABSTRACT
Nutrigenomics is a field that combines "nutrition" and "genomics." It focuses on how nutrients, both micronutrients and macronutrients, affect our genome. This includes understanding how nutrients interact with genes during transcription and gene expression, leading to varying responses based on different gene variants. One significant factor in this process is Transcription Factors (TFs), which are crucial for how nutrients influence gene activity. Several diseases, including cancer, diabetes, cardiovascular diseases, and dyslipidaemia, are linked to diet and nutrition. From a nutrigenomics perspective, conditions like diabetes and obesity often stem from an imbalanced diet that interacts with active genes. In daily life, nutrigenomics helps assess individual nutritional needs based on a person's genetic profile, which is sometimes referred to as personalized diet. This approach aims to prevent chronic diseases over time. However, nutrigenomics also raises ethical concerns, particularly regarding the privacy of individuals' genetic information and the need for further research in this area.

Keywords: Nutrigenomics, Nutrition, Genes, Chronic Disease, Literature Review

INTRODUCTION

Nutrition and the environment are key factors influencing human health. There is a connection between DNA metabolism and how the body changes based on various dietary factors, which serve as substrates in metabolic pathways. However, the effects of nutrient deficiency or excess on DNA replication are not well understood. It is important to recognize that while nutrients can influence biological processes, their effects also depend on an individual's genotype (Simopoulos et al., 2010). With advances in technology and knowledge in nutrition, a new field called Nutrigenomics has emerged. This research area seeks to understand how to manage health in groups of individuals who consume different diets. Nutrigenomics specifically studies how nutrients affect an individual's gene expression, but its definition has been broadened to include nutritional factors that can help protect the genome from damage (Palou et al., 2007).

Nutrigenomics examines the impacts of nutrients on the genome, proteome, and metabolome. The interaction between nutrients and cells or genes is referred to as nutritional genomics, which highlights the connections among genomic, biochemical, nutritional, and individual factors at the molecular level (Heyn et al., 2013). The goal of nutrigenomics research is to understand how the body responds to various diets and foods using advanced techniques such as genomics,

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transcriptomics, proteomics, and metabolomics. This area of research is expanding, particularly because metabolic and chronic diseases, such as obesity, are closely linked to both environmental and genetic factors, which play a significant role in health issues related to metabolic syndrome (Lau et al., 2008).

Concept of nutrigenomics

Nutrigenomics combines the concepts of "nutrition" and "genomics" to study how nutrients, both micronutrients and macronutrients, affect our genome and overall health. It explores the interactions between genes and nutrients or biologically active substances in food and their impact on human health. This area of study focuses on how nutrient activity influences transcription processes and gene expression, along with the responses that arise from different gene variants (Hocquette et al., 2005). Initially, nutrigenomics referred specifically to the effects of nutrients and bioactive foods on gene expression in individuals. However, its definition has expanded to include nutritional factors that protect the genome from damage (Hocquette et al., 2005). It examines the functions of the genome to understand how nutrient molecules affect metabolic pathways and maintain the body's balance. With nutrigenomics, scientists aim to determine how dietary changes can optimize health. An associated term, nutrigenetics, helps healthcare providers identify the best diet for each individual, recognizing that nutritional needs vary from person to person (Afman et al., 2006).

Nutrigenomics uses approaches such as transcriptomics, proteomics, and metabolomics, along with various advanced technologies. Nutrition can influence gene expression by regulating processes such as signal transduction and protein function. Genomics employs techniques like DNA sequencing to analyze the structure and function of the genome (Konstantinidi et al., 2019). This field provides insights into the mechanisms by which nutrients influence homeostatic processes and highlights interactions between food and genes, aiding in the selection of health-promoting foods. Nutrients can affect gene expression directly or indirectly, serving as ligands for transcription factors or undergoing metabolic processing influenced by other factors (Afman, 2006).

Transcription Factors (TFs) play a crucial role in how nutrient molecules alter gene expression. Nutrient sensors, like PPARs (Peroxisome Proliferator-Activated Receptors), are found in the human genome and bind to various nutrients and metabolites, influencing specific gene expressions involved in metabolic processes, such as those happening in the liver, fat metabolism, gluconeogenesis, and cell proliferation (Konstantinidi et al., 2019). In the nutrigenomic process, PPAR-δ receptors bind to fatty acids like palmitic (16:0), oleic (18:1n9), linoleic (18:2n6), and arachidonic acid (20:4n6), as well as eicosanoids like 15-deoxy-δ12 and 14-prostaglandin J2. These receptors act as sensors for fatty acids in the body, while retinoid receptors respond to compounds found in foods like vitamin A. These receptors impact gene expression by directly binding to nuclear receptors (Daimiel et al., 2012).

In metabolically active organs, such as the liver and intestines, transcription factors sense nutrient levels and modify gene transcription accordingly. Since nutrition can interact with an individual's genotype to affect phenotype, nutrigenomics can be used to explore the relationship between diet and genetic conditions (Masoli et al., 2022). Differences in genotype and nutritional deficiencies contribute to chronic diseases such as cancer, cardiovascular diseases, and inflammation. Nutrigenomics offers insights on how individuals can manage diseases through diet instead of relying solely on medications. Thus, it holds promise for developing personalized treatment approaches for individuals (Konstantinidi et al., 2019).

Nutrigenomics and non-communicable chronic diseases

Nutrition provides essential substances for the body, primarily serving as energy sources through carbohydrates and fats, structural components via proteins, and metabolic regulators through vitamins and minerals that help maintain homeostatic processes (Masoli et al., 2022). Each individual's nutritional status varies, influenced by a combination of factors including genetic background, physical health, and social and emotional circumstances. Diet plays a crucial role in metabolism, as the nutrients and other bioactive compounds in food can have beneficial effects or, conversely, lead to various health issues (Masoli et al., 2022).

Diet-related diseases include celiac disease, phenylketonuria, and non-communicable chronic diseases (NCCDs) such as cancer, diabetes mellitus, cardiovascular disease, and dyslipidemia. Nutrigenomics seeks to explain that a person's health is closely related to the interaction between their genes and dietary choices. This field, along with other "omics" sciences, aims to clarify how genes interact with bioactive compounds derived from food sources (Kiani et al., 2022). Nutrigenomics represents a new and evolving area focused on understanding the relationship between nutrition and genomics, particularly in relation to chronic diseases influenced by genetic factors. From an evolutionary standpoint, diet is believed to exert selective pressures on populations, much like environmental factors. Some genotypes may have heightened nutritional needs, and if these needs are not met, certain genotypes may be eliminated over time. Conversely, when nutritional needs, such as extra calories from carbohydrates and fats, are satisfied, the associated genomes can proliferate. This also applies to genotypes linked to obesity and diabetes mellitus (Uthpala et al., 2020).

From a nutrigenomics perspective, diabetes and obesity arise from unbalanced diets that interact with genes adapted during early human evolution when food resources were abundant. Today, these ancient genes are thought to lead to hormonal or metabolic tendencies that can become pathological. The risk of these diseases is influenced by genetic susceptibility and modern dietary patterns that contribute to insulin resistance (Dwivedi et al., 2017). As obesity is a significant risk factor for diabetes mellitus, cardiovascular diseases, and certain types of cancer, nutrigenomics is gaining emphasis in research. A study in Spain found that women with the Glu27 variant, who also consumed more than 49% of their total intake from carbohydrates, were three times more likely to be obese. However, alternative variants of the gene did not show a similar increased risk associated with carbohydrate intake (Dwivedi et al., 2017).

In the context of cardiovascular disease, nutrigenomics examines how nutrients affect gene expression in individuals. Research frequently uses Peripheral Blood

Mononuclear Cells (PBMCs) to assess changes in gene expression after nutrient intake. The study showed that increasing levels of high-density lipoprotein (HDL) cholesterol and triglycerides correlate with alterations in gene expression related to oxidative stress and inflammation, including changes in microRNAs and cytokines associated with inflammation (Kiani et al., 2022).

Chronic inflammation, often seen in cancer, can lead to significant cellular changes, such as increased DNA damage, impaired DNA repair pathways, uncontrolled cell proliferation, inhibited apoptosis, and enhanced angiogenesis and invasion. Cancer cells exhibit unique growth mechanisms. Omega-6 and omega-3 polyunsaturated fatty acids (PUFAs) have different effects on gene expressions related to inflammation (like TNFa, IL-1b, IL-6, IL-18), angiogenesis (like VEGF, PDGF, IGF-1, MMP-2), and proliferation (like cyclin, p53, Wnt, PTEN), all of which are crucial to cancer cell growth. However, further research is needed to understand the specific role of nutrigenomics in cancer (Ferland et al., 2012).

Nutrigenomics in everyday life

Nutrigenomics plays an important role in assessing the nutritional needs of individuals based on their genetic profiles, often referred to as a personalized diet. This approach aims to help prevent chronic diseases, which are becoming increasingly prevalent. Successful implementation of nutrigenomics requires not only an appropriate diet but also changes in lifestyle habits (Due et al., 2008).

Applying the principles of nutrigenomics offers several benefits, including (Ordovas et al., 2006):

Optimizing nutrient absorption. Understanding each individual's genetic predisposition allows for the identification of variations in nutrient absorption, utilization, and metabolism. This information can be used to create dietary programs that enhance the bioavailability of macronutrients and micronutrients while minimizing potential nutrient deficiencies (Ross et al., 2007).

Preventing and treating diseases. Nutrigenomics has the potential to support prevention programs and aid in the treatment of conditions such as obesity, cardiovascular disease, diabetes, and some cancers. By tailoring diets to genetic factors, individuals may maintain better health and reduce their risk of certain diseases (Stover et al., 2008).

Precision medicine. Nutrigenomics aligns with the principles of precision medicine, which tailors treatment based on individual characteristics. By using genetic data to guide dietary programs, treatment can become more targeted and effective (Lim et al., 2023).

Weight management. Personalized nutrition design can enhance weight management strategies. Since genetic factors influence individual responses to various diets, nutrigenomics can help identify the most effective methods for weight loss or maintenance (Stover et al., 2008).

Athletic Performance. Nutrigenomics can optimize nutrition for athletes based on genetic influences, improving energy metabolism, muscle recovery, and overall performance (Ross et al., 2007).

Reducing Trial and Error. Personalized nutritional adjustments based on genetic information can decrease the trial and error often involved in sticking to a diet.

Nutrigenomics can enhance adherence to dietary programs by providing reliable information and saving time (Lim et al., 2023).

Future challenges of nutrigenomics

Despite its advantages, nutrigenomics presents several ethical concerns. These include the potential for increasing anxiety about disease risk, threats to patient confidentiality, possible discrimination by health insurance companies and families, and the need for qualified health professionals who specialize in this area, along with unforeseen risks (Mullins et al., 2020).

Professionals aiming to apply nutrigenomics in the future will face several challenges (Mullins et al., 2020):

Privacy and genetic information. Nutrigenomics relies on individual genetic data, making privacy a primary concern. Protecting sensitive genetic information from unauthorized access and ensuring patient confidentiality are critical. Addressing these issues is vital for building trust in nutrigenomics applications (Mullins et al., 2020).

Access to nutritional information. The availability of personalized nutrition based on genetic information can be affected by socio-economic factors. Future efforts must focus on bridging access gaps to ensure diverse populations benefit from nutrigenomics without contributing to health disparities (Philips et al., 2006).

Influence of environmental factors. Nutrigenomics must consider not only nutrition but also environmental factors that can affect gene expression. Lifestyle, socio-economic status, and environmental exposures can modulate genetic influences. Understanding these complex interactions is essential for effective personalized nutrition recommendations (Mullins et al., 2020).

Need for further research. The field of nutrigenomics is dynamic and continuously evolving. Ongoing research is necessary to deepen our understanding of gene-nutrient interactions, identify additional genetic markers, and refine personalized nutrition guidelines. Continued exploration will ensure that nutrigenomics remains a viable treatment option (Mullins et al., 2020).

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