Physical Education, Health and Social Sciences

https://journal-of-social-education.org

E-ISSN: 2958-5996

P-ISSN: 2958-5988

Genetic Variation and Personalized Nutrition: A Review of Dietary Needs Based on Genetic Variation

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DOI: https://doi.org/10.63163/jpehss.v3i3.604

Abstract

Genetic Variations are known to affect how different human populations put up with food and meet their dietary needs, resulting in the rise of nutritional geonomics. However, because the relation between genes and diet is tangled and not yet fully understood, implementing genetic information to wide dietary guidelines carry people probable risks. Personalized nutrition or nutrigenetics is an emerging field that seeks to make dietary recommendations to individual's genetic profile. The success of nutrigenetics not only depends on science but also on consumer acceptance and uptake. By understanding how genetic differences shape nutrient metabolism, researchers are hopeful to appear with personalized nutritional plans that will improve health for each individual based on their unique genetic profiles. This review article provides a concise overview of nutrigenetics and its relation to dietary needs, limitations and the future perspectives of personalized nutrition.

Keywords: Nutrition, Personalized Nutrition, Genetics, Genetic Variability, Nutrigenetics, Nutrigenomics, Diet, Dietary Interventions.

Introduction

Genetic variation is result of subtle differences in our DNA. Genetic variation refers to the differences in the nucleotide sequence of DNA within and between individuals of a specie [1]. Personalized nutrition is a tailored diet that provides population-based nutritional advice to a particular person's need while considering their genetic makeup. Personalized nutrition is the end of one-diet-fits-all era. A personalized nutritional plan takes account into your all-specific characteristics such as health needs, lifestyle, goals and even genetic factors because all dietary guidelines may not be suitable for all the individuals due to the variation in genetic composition of different individuals [2, 3]. In the recent years (from last 8 to 10 years) people start to consider their dietary needs and increasingly understanding that one-diet-fits-all approach to nutrition is insufficient to fulfill all their health needs. Genetic variation plays a vital role in determining the different individual's metabolism, how their bodies respond to different diets and develop nutrition related diseases. Researches on Genetic variation have opened up new possibilities in the field of nutrition, diverting the focus from generalized dietary guidelines towards highly personalized recommendations. Furthermore, understanding gene-diet interaction helps to prevent several high-

risk diseases such as Obesity, Diabetes, Cardiovascular diseases and certain food intolerances [4, 5]. Nowadays, it is undeniable that personalized nutrition indicating the right food for all based on genetic makeup of an individual is an ongoing trend in our society [6]. Herein, we examine how dietary needs of individuals are influenced by their genetics and highlight the importance of personalized diet in strengthening their health outcomes.

Nutrigenetics and Nutrigenomics

Nutrigenetics is the study of the phenotypic different responses to diet considering the genetic variability between individuals [7]. Nutrigenomics represents the dynamic interface between nutrition and genomic-regulated processes [8]. It is substantial to clear the difference between nutrigenetics and nutrigenomics because these two terms are just closely related but not interchangeable. Nutrigenetics investigates the modifying effects of inheritance or mutations [11]. Nutrigenomic identifies the genetic variations that why some people react differently to dietary components. Individuals respond differently to various nutrients. This is because of genetic variations [9]. Nutrigenomic helps us in research regarding to genes and molecular pathways in the originations of abundant diseases and assist us to bring forward more ways to prevent these diseases [10]. It is evident that nutrigenomics and nutrigenetics are the areas of research that can help us understand how our genes and food effect our health. Scientists are using different technologies and biomarkers to study this aspect, and it appears like these studies will be beneficial for the future [9,10].

Influence of genetic variations on specific nutritional needs

Here are some examples of specific nutritional requirements that have been influenced by genetic variability:

- **MTHFR Gene and Folate Metabolism:**
  Some people have changes (mutations) in MTHFR gene which is continuously reducing their ability to process folate (vitamin B9) causing a rise in homocysteine level. It results in high-risk conditions such as hypertension, blood clots, pregnancy loss and certain type of cancer [12].
  Folate is highly essential in women during pregnancy for preventing neural tube defects (NTDs) and development of babies. Folate is essential for the growth of fetus's brain and spinal cord. In typical days, women should make a habit of folic acid intake for healthy reproductive system and to prevent anemia [13, 14].
- **LCT Gene and Lactose Intolerance**
  Lactose is one of the main sources of carbohydrates a primary source of energy during the lactation period for mammals. To digest lactose from milk, mammals first break it down into simpler sugar components [23]. In humans, the potential to soak up milk lactose is vested by Beta-galactosidase enzyme also known as Lactose-Phlorizin hydrolase (LPH). The LPH enzyme is encrypted by the lactase gene, found on chromosomes [15].
  The LCT gene is responsible for lactose reproduction. It is a large gene present on chromosomes and spans about 49.3 kb of DNA. It contains 17 axons and is transcribed into a 6 kb RNA transcript [16].
  Lactose intolerance is a common disorder that arises when the body struggles to digest lactose and causes gastrointestinal diseases. Lactose digestion disorders and dairy product intolerances are common human gastrointestinal dysfunction [17].
- **VDR Gene and Vitamin D Metabolism**
  Vitamin D activity is controlled by the VDR. VDR gene is one of the most commonly analyzed gene in the patients with type 1 diabetes. The high variability in VDR

polymorphisms is associated with risks such as osteoporosis [19, 20]. Vitamin D that is a fat-soluble vitamin, is also known as a molecule and its production is increased by exposure to sunlight that do not burn the skin. The deficiency of vitamin D can cause several diseases, mainly rickets [18, 19, 20, 21].

Personalized nutrition based on genetic variation:

Personalized nutrition makes use of the unique characteristics of people to draw up approaches focused at curing diseases and improving overall health [24].

Personalized nutrition is progressively getting attention in all medical fields, Professionals are using genetic testing to treat people with chronic diseases [22]. Poor nutrition is the major cause of deaths worldwide. Personalized nutrition in needed to prevent people from these diseases and deaths [25].

Benefits of genetic-based dietary recommendations:

Various aspects of personalized nutrition (PN) are used in nutritional fields such as customized diet, lifestyle and future goals [26]. Some benefits of genetic-based dietary recommendations are;

- **Targeted nutritional intake:**
  Personalized nutrition focuses on specific diet for an individual at a specific time, enhancing absorption and usage of diet. For example, a person with diabetes can benefit by taking diet that can regulates the blood sugar level [27, 29].
- **Weight management:**
  Genetic variations result in changes in the body's metabolism of a person. People with specific gene variations can benefit by increasing their intake of that nutrient rich healthy food to improve their overall health [28]. Genetic variability affects the fat metabolism of the body due to which a person starts to gain weight [29]. When body becomes nutrient deficient the person starts losing weight. Personalized nutrition addresses genetic differences and helps to achieve and maintain good healthy weights [30].
- **Disease prevention and management:**
  Personalized nutrition helps to prevent chronic diseases such as diabetes, cardiovascular diseases and certain inflammatory diseases [31]. By understanding gene-diet interactions, it is possible to to adopt strategies that can lower and manage diseases [32].
- **Enhanced gut health:** Gut health also refers to the digestive wellbeing also needs attention. gut microbes a community of microorganisms living in the digestive tract behaves differently to different foods to maintain healthy gut [33]. Diseases like IBS and Crohn's diseases can be managed by incorporating gut friendly nutrients [33, 34].
- **Improved mental and emotional health:**
  What a person eats can affect his mental health [35]. A person's lifestyle also have an influence on their mind and emotional wellbeing. By eating foods rich in anti-oxidants and boosting brains energy level can cope with the mental health and improves mood swings (emotional health) [36, 37].

Future perspectives:

The future of genetic-based dietary recommendations has a revolutionary value in the field of medical science. Future dietary recommendations will fetch data from genomics, epigenomics and microbiomes. There will be machine learning algorithms to continuously refine adaptive personalized nutrition advice system [38]. There will be advancements in nutrigenomic technologies and AI driven tools to enhance dietary recommendations and health outcomes [39, 40].

Challenges and considerations:

Genetic-based dietary recommendations are much valuable but scientific validation is necessary to determine the efficacy of these approaches. The use of genetic data gives rise to the question of ethnicity and data privacy including potential misuse of genetic information [41, 42]. Personalized nutrition should be accessible to all individuals to maintain equity and to prevent several health disparities [42, 43]. While ongoing suggestions are planned to meet the requirements of most and prevent deficiencies, incorporating genetic awareness might reveal that several groups benefit differently, or even face risks, under the same guidelines and fortification policies [42].

Conclusion:

Genetic variations play a crucial role in shaping nutritional needs of individuals according to their genetic makeup. Understanding of Genetic variability open ups new possibilities to deepens our knowledge of personalized nutritional recommendations based on individual's genotype. This approach has potential to reduce risks and to promote wellbeing in old age. There are still some challenges including consumer acceptance and further validation. With the advancement in technology personalized nutrition will likely to play a beneficial role in preventing diseases and promoting longevity in diverse population. Genetic variety is essential in defining how each person reacts to different dietary components, impacting disease susceptibility, nutrient metabolism, and general health outcomes. The fields of nutrigenomics and nutrigenetics have advanced, offering fresh perspectives on how certain genetic variations can direct the creation of individualized dietary plans. By combining genetic profiling with conventional food evaluation, medical practitioners can steer clear of broad suggestions and toward more targeted, efficient, and long-lasting treatments. However, obstacles like high testing costs, low public awareness, ethical issues, and the requirement for more robust evidence from extensive, longitudinal research must be overcome before personalized nutrition can be used in practice. In order to develop comprehensive nutritional recommendations, future research should concentrate on closing these gaps by integrating genetic data with lifestyle, environmental, and microbial factors. Finally, there is promise to improve health, prevent disease, and usher in a new era of precision dietary care by integrating genetic diversity into nutrition practice.

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