Nutrigenomics

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Nutrigenomics is a branch of nutritional genomics and is the study of the effects of foods and food constituents on gene expression.[1] This means that nutrigenomics is research focusing on identifying and understanding molecular-level interaction between nutrients and other dietary bioactives with the genome. Nutrigenomics has also been described by the influence of genetic variation on nutrition, by correlating gene expression or SNPs with a nutrient's absorption, metabolism, elimination or biological effects. By doing so, nutrigenomics aims to develop rational means to optimise nutrition with respect to the subject's genotype.

By determining the mechanism of the effects of nutrients or the effects of a nutritional regime, nutrigenomics tries to define the causality or relationship between these specific nutrients and specific nutrient regimes (diets) on human health. Nutrigenomics has been associated with the idea of personalized nutrition based on genotype. While there is hope that nutrigenomics will ultimately enable such personalised dietary advice, it is a science still in its infancy and its contribution to public health over the next decade is thought to be major.[2] Whilst nutrigenomics is aimed at developing an understanding of how the whole body responds to a food via systems biology, research into the effect of a single gene/single food compound relationships is known as nutrigenetics.[3]

Contents

Definitions

Nutrigenomics has been defined as the application of high-throughput genomic tools in nutrition studies and research.[4] It can also be seen as research to provide people with methods and tools who are looking for disease preventing and health promoting foods that match their lifestyles, cultures and genetics.

The term "high throughput tools" in nutrigenomics refers to genetic tools that enable millions of genetic screening tests to be conducted at a single time.[5] When such high throughput screening is applied in nutrition research, it allows the examination of how nutrients affect the thousands of genes present in the human genome. Nutrigenomics involves the characterization of gene products and the physiological function and interactions of these products. This includes how nutrients impact the production and action of specific gene products and how these proteins in turn affect the response to nutrients.[6]

Background and preventive health

Throughout the 20th century, nutritional science focused on finding vitamins and minerals, defining their use and preventing the deficiency diseases that they caused. As the nutrition related health problems of the developed world shifted to overnutrition, obesity and type two diabetes, the focus of modern medicine and of nutritional science changed accordingly.

To address the increasing incidence of these diet-related-diseases, the role of diet and nutrition has been and continues to be extensively studied. To prevent the development of disease, nutrition research is investigating how nutrition can optimize and maintain cellular, tissue, organ and whole body homeostasis. This requires understanding how nutrients act at the molecular level. This involves a

multitude of nutrient-related interactions at the gene, protein and metabolic levels. As a result, nutrition research has shifted from epidemiology and physiology to molecular biology and genetics[2] and nutrigenomics was born.

The emergence and development of nutrigenomics has been possible due to powerful developments in genetic research. Inter-individual differences in genetics, or genetic variability, which have an effect on metabolism and on phenotypes were recognized early in nutrition research, and such phenotypes were described. With the progress in genetics, biochemical disorders with a high nutritional relevance were linked to a genetic origin. Genetic disorders which cause pathological effects were described. Such genetic disorders include the polymorphism in the gene for the hormone Leptin which results in gross obesity. Other gene polymorphisms were described with consequences for human nutrition. The folate metabolism is a good example, where common polymorphisms (C677T and A1298C) exists for the gene that encodes the methylene-tetrahydro-folate reductase (MTHFR).

It was realized however, that there are possibly thousands of other gene polymorphisms which may result in minor deviations in nutritional biochemistry, where only marginal or additive effects would result from these deviations. The tools to study the physiological impact were not available at the time and are only now becoming available enabling the development of nutrigenomics. Such tools include those that measure the transcriptome - DNA microarray, Exon array, Tiling arrays, single nucleotide polymorphism arrays and genotyping. Tools that measure the proteome are less developed. These include methods based on gel electrophoresis, chromatography and mass spectrometry. Finally the tools that measure the metabolome are also less developed and include methods based on nuclear magnetic resonance imaging and mass spectrometry often in combination with gas and liquid chromatography.

Rationale and aims of nutrigenomics

In nutrigenomics, nutrients are seen as signals that tell a specific cell in the body about the diet. The nutrients are detected by a sensor system in the cell. Such a sensory system works like sensory ecology whereby the cell obtains information through the signal, the nutrient, about its environment, which is the diet. The sensory system that interprets information from nutrients about the dietary environment include transcription factors together with many additional proteins.

Once the nutrient interacts with such a sensory system, it changes gene expression and metabolite production in accordance with the level of nutrient it senses. As a result, different diets should elicit different patterns of gene expression and metabolite production. Nutrigenomics seeks to describe the patterns of these effects which have been referred to as *dietary signatures*. Such dietary signatures are examined in specific cells, tissues and organisms and in this way the manner by which nutrition influences homeostasis is investigated. Genes which are affected by differing levels of nutrients need first to be identified and then their regulation is studied. Differences in this regulation as a result of differences in genes between individuals are also studied.[2]

It is hoped that by building up knowledge in this area, nutrigenomics will promote an increased understanding of how nutrition influences metabolic pathways and homeostatic control, which will then be used to prevent the development of chronic diet related diseases such as obesity and type two diabetes. Part of the approach of nutrigenomics involves finding markers of the early phase of diet related diseases; this is the phase at which intervention with nutrition can return the patient to health. As nutrigenomics seeks to understand the effect of different genetic predispositions in the development of such diseases, once a marker has been found and measured in an individual, the extent to which they are susceptible to the development of that disease will be quantified and personalized dietary recommendation can be given for that person.

The aims of nutrigenomics also includes being able to demonstrate the effect of bioactive food compounds on health and the effect of health foods on health, which should lead to the development of functional foods that will keep people healthy according to their individual needs.

Nutrigenomics is a rapidly emerging science still in its beginning stages. It is uncertain whether the tools to study gene expression and metabolite production have been developed to the point as to enable efficient and reliable measurements. Also once such research has been achieved, it will need to be integrated together to produce results and dietary recommendations. All of these technologies are still in the process of development.

Application of Nutrigenomics

Anti-aging

Aging of cells occur because of the accumulation of excess free radicals formed due to the lack of proper nutrition to the cells and external factors like UV rays, pollution, stress, food, etc. DNA analysis is instrumental in identifying the right concoction of nutrients needed to eliminate the excess free radicals present in the cell.

The science of nutrigenomics studies the interaction between dietary components of food and genes.[7] Scientific advances have now made it possible to apply nutrigenomics in the field of anti ageing and customize nutritional solutions in the form of supplements to meet the optimal nutrition required by the body to prevent ageing of cells by the formation of excess free radicals.[8][9]

Obesity

Obesity is one of the most widely studied topics in nutrigenomics. Due to genetic variations among individuals, each person could respond to diet differently. By exploring the interaction between dietary pattern and genetic factors, nutrigenomics aim to suggest prevention measures and/ or treatment to obesity via personal nutrition.[10]

There are studies suggesting genetic factors account for a fair proportion of inter-individual BMI.[10] Among different types of genetic variation between humans, SNPs are suggested to be the most important marker for the study of nutrigenomics.[10]

Multiple studies have found association between SNPs and obesity. One of the most well known obesity associating gene is the FTO gene. Among studied individuals, it was found that those with AA genotype showed a higher BMI compared those with TT genotype when having high fat or low carbohydrate dietary intake.[10][11]

The APO B SNP rs512535 is another obesity related variation. It was found that the A/G heterozygous genotype was found to have association with obesity (in terms of BMI and waist circumference). The same study also found that for

individuals with habitual high fat diet (>35% of energy intaken), individuals with GG homozygotes genotype showed higher BMI compared to AA allele carriers. However, this difference is not found in low fat consuming group (<35% of energy intaken).[10][12]

Besides the FTO genes and APO B, SNPs in various genes such as MC4R, SH2B1, MTCH2, SEC16B etc. have been found to be associated with obesity.[10] Although many of these genetic variations are found in populations all over the world, there are also variations unique to certain races or populations.[10]

Ethics

To put nutrigenomics into practice, genetic testing is required as the test results act as the reference for diagnosis. As the subject is recently commercialized by companies which sell direct to customer (DTC) genetic tests, as well as being applied by related professionals (such as dietic practitioners), there have been increased awareness in the use of this information.[13]

These concerns include but are not limited to the lack of analytical and clinical validity of genetic tests, emotional distress of consumers, and other social concerns.[13]

Privacy

One of the major concerns regarding genetic tests would be privacy issue. There are concerns on who has the right to have access to test results. Abuse of these tests could result in discrimination. For example, genetic information might be used by insurance companies to risk rate their clients.[14]

Medical claims

One of the possible ethical concerns arise would be private companies providing unverified information regarding test results. For example, there are concerns on test-providing companies making unproven medical claims, as well as selling unnecessary or over-priced supplements.[14] Interpretations on genetic test results

needs to be handled very carefully. Misinterpretation could possibly mislead patients and hence false medical claims are made. Misleading and/or inaccurate information may as well undermine customers' ability to make informed decisions.[15]

Validity of nutrigenomic tests

Nutrigenomics is the study of interactions between a person's genetics and nutrition. In order to make accurate interpretations of genetic test results, sufficient genetic and nutritional knowledge is necessary for the practitioner. However, there are currently no regulations limiting who can perform these tests. As well, nutrigenomics is not currently a licensed profession. Therefore, there are concerns regarding the validity of consultation provided by private companies on genetic test results.[14] In other words, there are concerns about how well the companies (who sell this services, and therefore have a profit motive) interpret test results.

See also

- Diet (nutrition)
- Foodomics
- Nutriomics
- Nutritional gatekeeper
- Nutritional genomics
- Nutrigenetics
- Orthomolecular medicine
- Public Health Genomics

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Further reading

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