

Perspective

The importance and strategy of diabetes prevention

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Received 9 October 2016

Available online 20 December 2016

Abstract

Diabetes has become one of the largest public health problems to date. Decreased physical activity, overnutrition, and nutrition transitions caused by changes in lifestyle contribute to the increasing incidence of chronic metabolic diseases as well as deaths related to them. The shift from undernutrition to overnutrition indicates that chronic diseases of affluence have become a public health problem; hence, sustainable health-related goals have been developed for the prevention of these diseases. Environmental factors and the gut microbiota influence metabolism in the human body. Several studies have proven that lifestyle interventions can effectively deter the progression of diabetes in individuals with impaired glucose tolerance. If the window of prevention is shifted earlier, diabetes may become a fortuitous event. Effective prevention needs high attention from the government and the participation of all citizens. Concrete scientific and reasonable measures also need to be developed by experts and scholars.

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Keywords: Chronic metabolic diseases; Diabetes; Prevention

For nearly half a century, along with the social development and lifestyle changes, chronic metabolic diseases, mainly obesity, type 2 diabetes, abnormal lipid metabolism, and coronary heart disease, have become diseases that threaten human health and are now one of the biggest public health problems. Statistics show that more than 2 billion people are overweight or obese, and nearly 400 million patients currently suffer from diabetes mellitus globally.^{1,2} In 2010, it was reported by the *New England Journal of*

Medicine that the prevalence of type 2 diabetes was 9.7% among Chinese individuals over 18 years of age, and the total number of the patients in China was more than 92 million.³ Three years later, the *Journal of the American Medical Association* published another Chinese diabetes epidemiological study showing that the prevalence rate of diabetes in Chinese adults was as high as 11.6%, with the total number of patients reaching 114 million, accounting for about a third of the total number of patients worldwide.⁴ However, in 1980, at the initial stage of China's reform and opening up, a census on 300,000 people from 14 provinces and cities in China showed the prevalence rate of diabetes as only 0.67%.⁵ China is the world's largest developing country and has a large population. Therefore, the prevalence of diabetes in China has the largest impact globally and can be regarded as representative of the

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Peer review under responsibility of Chinese Medical Association.



Production and Hosting by Elsevier on behalf of KeAi

<http://dx.doi.org/10.1016/j.cdtm.2016.11.013>

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general population. Diabetes, the main component of chronic metabolic diseases, not only lowers quality of life and greatly increases medical expenses, but also significantly increases disease-related deaths. Diabetes has become one of the major diseases that result in death. Each year, the number of deaths from diabetes and its complications exceeds 3.8 million.⁶ In developed and developing countries, diabetes and diabetic cardiovascular diseases (CVDs) have become major causes of death. In underdeveloped areas, although infectious disease is still a predominant cause of death, obesity and diabetes, and metabolic disease-related deaths have been rising rapidly in recent years.

The increase in diabetes and other chronic metabolic diseases, as well as the resultant deaths, has certain causality with decreased infectious diseases and human longevity, but is more attributable to overnutrition, nutrition transition, and decreased physical activity caused by lifestyle changes. The transition from undernutrition to overnutrition indicated that developing populations failed to sustain economic development and food security, resulting in the emergence of CVDs and other chronic diseases.⁷ Increased consumption of western-type diets, in addition to lower intake of functional food rich diets, has been associated with an epidemic of metabolic syndromes, blood pressure variability, and blood glucose variability disorders.⁸ Currently, chronic metabolic diseases are increasing in all age groups. Obesity and diabetes gradually became the main diseases in the United States, Europe, and other developed countries in the 1970s and 1980s, and then a major public health problem in Brazil, Russia, India, China, and other countries. This pattern is in agreement with the premise that nutrition transition is due to changes in social and economic development. Ingestion of processed and fast food; foods high in fat, sugar, and calories; animal products; and beverages high in sugar and calories have replaced traditional food and changed eating habits. Food transition varies by country and region; however, the overall trend is an increasing proportion of fat and animal products and decreasing proportion of carbohydrates. Some diets have transitioned from the intake of carbohydrates from coarse grains to the intake of carbohydrates from processed and sugary foods. The calories in this type of diet are much higher, resulting in higher caloric output than that required by the body and an increased risk of obesity and diabetes. Additionally, this type of diet can cause chronic metabolic-related inflammation and induce metabolic diseases such as diabetes and CVDs. In the 1990s, it was found that obese people had signs of chronic inflammation, which

promoted the concept of metabolic inflammation (metaflammation). This inflammation is more apparent when obesity and diabetes occur as comorbidities.⁹

The influence of environmental factors on human metabolism can be observed throughout lifespan. A poor lifestyle of the mother during pregnancy may lead to early life chronic metabolic diseases in the child. Poor nutrition during the embryonic period may induce the formation of “thrifty” genes in the fetus; obesity and metabolic disorders will appear when the postnatal baby receives adequate nutrition. Excess intake or glucose metabolism disorder in the mother during pregnancy can cause fetal nutrition surplus and high insulin hematic disease, which are key factors contributing to macrosomia and obesity in children. In recent years, the fast growing incidence of gestational diabetes is an indicator of metabolic disturbances in the next generation. The adverse influence of modern lifestyle on child and adolescent health is more significant, with the young generation, during the early stage of China's reform and opening up, growing up exposed to western foods such as KFC, McDonald's, and Coca-Cola.

Recent results from the *Prevención con Dieta Mediterránea (PREDIMED)* study, as well as others, indicate that Mediterranean style diets can cause significant decline in CVDs, type 2 diabetes, and cancer.^{10,11} The beneficial effects of Mediterranean style diets may be due to the prominence of fruits, vegetables, nuts, fish, poultry, and olive oil, and foods with a low glycemic index, but very little red meat.⁷ The majority of these foods possess increased content of polyphenolic flavonoids, carotenoids, omega-3 fatty acids, antioxidants, vitamins, and minerals, as well as essential and non-essential amino acids which may influence the brain-body interactions contributing to CVDs and diabetes.¹²

Another important piece of evidence illustrating the correlation between chronic metabolic diseases and the gut microbiota was found in recent years. The human intestine contains approximately 100 trillion microorganisms, comprising up to 1000 different species. The gut microbiota weights approximately 2 kg and its genome, which is called “the other genome”, carries at least 100 times as many genes as the whole human genome.¹³ It has been reported that a significant increase of the *Firmicutes/Bacteroidetes* ratio, a decrease of *Lactobacillus* and *Bifidobacterium* (known as beneficial bacteria), and an increase of *Clostridium* (known as harmful bacteria) can be observed in the obese population.¹⁴ The variation in the gut microbiota may change energy metabolism, which can lead to, and

further aggravate, obesity; from another aspect, it can induce chronic inflammation as well. Undoubtedly, variation in the gut microbiota closely relates to environmental factors, especially dietary factors. Dietary and environmental factors can trigger dysbiosis, which in turn affects the host-microbe interactions, essentially leading to effects on the host energy metabolism. Increasing evidence indicates that the variation in the gut microbiota may have a great influence on body weight and energy metabolism.

In the face of the rapid growth of diabetes and other chronic metabolic diseases, many governments, institutions, and pharmaceutical companies have invested large amounts of money to study the pathogenesis and seek new treatment. Indeed, new drugs and technologies have been continuously emerging. Yet they do not control the rapid growth of patients with diabetes: the more patients are treated, the more new cases are found. The prognosis of diabetes has not gained fundamental progress either. This is mainly because, thus far, disease prevention has not been included in the agenda worldwide; and no effective measures have been taken to prevent the diseases from the source.¹⁵

Can diabetes be prevented? In fact, the conclusion is very clear. In 1986, the first study in China investigating diabetes prevention was conducted in Daqing, where patients with impaired glucose tolerance (IGT) received lifestyle intervention, including diet control and exercise.¹⁶ The study was followed by the Diabetes Prevention Study (DPS) in Finland and the American Diabetes Prevention Program (DPP).^{17,18} These studies have proved that lifestyle intervention can effectively deter the progression of diabetes for patients with IGT. In 2008, the Sino-Japanese Friendship Hospital, Daqing First Hospital, and the Centers for Disease Control and Prevention of the United States completed the “20-year follow-up study of China Daqing Diabetes Prevention”, which reported that 92% of the population with high diabetes risk were diagnosed with diabetes in the absence of intervention in 20 years; however, the figure was reduced by 43% after 20 years with only a six-year-long lifestyle intervention.¹⁹ These results illustrated that lifestyle intervention for diabetes prevention is definite and long-lasting. Lifestyle intervention not only contributes to effectively reducing blood glucose level during the strengthened intervention period, but also perhaps to improving healthy habits developed during the intervention. The Daqing study explained the influence of lifestyle intervention on macrovascular and microvascular diseases as well: lifestyle intervention reduced the mortality rates of cardiovascular and cerebrovascular diseases by 17%,

and the incidence of severe microvascular disease by 47%, in 20 years.¹⁹ For those with poor compliance or ineffective lifestyle intervention, drug intervention can be used. The DPP observed that metformin administration to patients with IGT delayed diabetes by 2.8 years. The European multi-center study of diabetes prevention by acarbose (STOP-NIDM) revealed that a 3-year-long acarbose drug intervention can decrease the risk of type 2 diabetes in people with IGT by 36%.²⁰ As previously mentioned, the reported studies were carried out in patients with abnormal glucose metabolism. Although there were statistically positive results, the prevention results are incomplete because once the biochemical markers with abnormal glucose metabolism appear, the foundation of diabetes development has accumulated to a considerable degree. If the window of prevention was shifted earlier, with a healthy lifestyle maintained for most of life, diabetes may become a fortuitous event.

Theoretically, the prevention of diabetes can definitely be successful, and feasible as well. The rapid increase in the incidence of diabetes corresponds with the recent environmental and lifestyle changes. Long-term excessive calorie intake, increased intake of dietary protein and lipids, and reduced physical activities are the core factors in diabetes development. Thus, it will undoubtedly achieve great success to begin with adjustment of lifestyle changes.

Around 2000 years ago, China's first medical book *Yellow Emperor's Canon* recorded: “It (diabetes) will occur in the fertile population, who are obese due to eating more sweet food. Obesity generates endogenous heat and sweet food leads to abdominal fullness, so the *qi* overflows, and turns into diabetes.” Endogenous heat refers to agitation and thirsty; and abdominal fullness refers to the trunk full of fatness. In traditional Chinese medicine *qi* (gas) refers to an inherent function of the body, controlling the body's metabolism (operation), and *qi* overflow refers to the disorder of the inherent function of the body resulting in an abnormal red facial, sanguine temperament and acne, etc. In later publications, medical books had similar conclusions. In the *Jing Yue Pandect* of the Ming Dynasty, Zhang Jie-bin said “The origin of diabetes is due to consumption of too much sweet food and fat, ... the disease is common among rich people and rare among poor people.” The Chinese people clearly predicted the cause of diabetes thousands of years ago. Perhaps today's esoteric principles and abstract modern scientific theories obscure judgment abilities. The principle of diabetes prevention is very clear, and the effect is not difficult to predict. An increasing number

of theoretical studies are being conducted by scientists, which in turn influence the government's actions. Unfortunately, the prevention of diabetes is not feasible without government intervention. This may be the fundamental reason why a huge investment is put into the field of diabetes research and treatment while the incidence and detriment of diabetes continue to increase. Of course, the difficulty of chronic metabolic disease prevention like diabetes is significantly higher than previous issues, like iodine deficiency disease prevention.

Prevention of diabetes requires reshaping and maintaining a new way of life. First, diabetes prevention requires constraints on human behavior, scientific guidance, and years of persistence and self-discipline. Second, the effect of diabetes prevention may manifest 10 or even 20 years later, which is difficult to be recognized by today's evaluation system since society prefers quick success and instant benefits. In spite of the above, the necessity of organizing prophylactic activities of different types such as education and screening is obvious, and prophylactic programs should be carried out at local or more general levels. Diabetes prevention is likely to bring huge benefits for individuals, countries and the entire human race, and incalculable conservation for society resources as a whole.

Prevention of diabetes and other chronic metabolic diseases has become extremely important, requiring prompt action of individuals, society, and government. It requires experts to put forward proposals and specific approaches, governments to increase education, and the active participation of all citizens. If these approaches are used, then diabetes and other chronic metabolic diseases would no longer be unconquerable diseases affecting human health, and their prevention would greatly enhance the quality of life.

Conflicts of interest

The author declare that he has no conflicts of interest.

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