Journal of Nutrition and Food Security
Shahid Sadoughi University of Medical Sciences
School of Public Health
Department of Nutrition
Nutrition & Food Security Research Center

eISSN: 2476-7425 pISSN: 2476-7417 JNFS 2016; 1 (1): 73-79 Website: jnfs.ssu.ac.ir

A Review of the Relationship between Dietary Glycemic Index and Glycemic Load and Type 2 Diabetes

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ARTICLE INFO

REVIEW ARTICLE

Article history:
Received: 9 Apr 2016
Revised: 5 Jun 2016
Accepted: 24 Jul 2016

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ABSTRACT

Background: In recent decades, studies on type 2 diabetes (T2D), have adopted a new approach to the field of a more complete collection of variables related to the lifestyles and diet of people. Diet is an important factor in increasing the rate of T2D among individuals. Considering the consumption of a high-carbohydrate diet, little attention has been paid to the type of carbohydrates consumed in the incidence of T2D. The present study aimed to review the literature on the relationship between the glycemic index (GI), the glycemic load, (GL) and T2D, it also targets at evaluating and comparing the results of similar studies in other countries **Methods**: Using search engines, including PubMed, Science Direct, Embase and Scopus, and key words such as GI, GL, diabetes; articles with cross-sectional, clinical trial, Prospective and retrospective cohort designs between 2000 to 2016 were selected. Moreover, non-English language articles were not investigate. **Results**: The results of these studies showed that a diet containing low GI and GL has beneficial effects on the metabolism of glucose in the body and is also considered as a factor to protect the body against T2D and its complications. **Conclusions**: Monitoring eating habits of people with T2D can have beneficial effects on T2D and its associated risk factors.

Keywords: *Diabetes; Glycemic load; Carbohydrat; Glycemic index*

Introduction

In recent decades, the pattern of diseases has been changed due to enhanced quality of health services and vaccination. This pattern proceeds towards the reduction in communicable diseases and increase in chronic diseases, particularly type 2 diabetes (T2D). T2D is a disease, associated with obesity, insulin

This paper should be cited as: Zeinali F, Asadi Samani H, Toupchian O, Abdollahi Sh, Samadi M. ***A Review of the Relationship between Dietary Glycemic Index and Glycemic Load and Type 2 Diabetes.*** *Journal of Nutrition And Food Security (JNFS)*, 2016; 1 (1): 73-79.

[DOR: 20.1001.1.24767417.2016.1.1.4.1]

resistance, hypertension, and high concentration levels of triglycerides (Ebrahimi *et al.*, 2008). Diabetes mellitus is diagnosed with hyperglycemia, impaired metabolism of carbohydrates, fats and proteins, and absolute lack of insulin. The disease is one of the most common and costly chronic diseases worldwide, the prevalence of which is increasing due to the lifestyle changes and improvement of the health status of communities, which results in the increased survival rate. The disease affects all races differently. The prevalence and incidences of this disease has increased in many societies, especially in developing countries. Currently, diabetes is the fourth leading cause of death in most countries. In recent decades, epidemiologic studies have been conducted on T2D in Iran, based on which the population of patients with diabetes was estimated to be more than 1.5 million (Larejani and Zahedi, 2001). The recent studies indicated high prevalence rate of diabetes in the Iranian population (Ebrahimi *et al.*, 2008, Larejani and Zahedi, 2001). The epidemiologic studies showed that the lifestyle and specially eating habits play a major role in the incidence of T2D. It is expected to reduce the prevalence rate of the disease and its complications by changing the eating habits. Since carbohydrates make up the bulk of food in our country and most Asian countries, it is recommended to consider the type and amount of carbohydrate intake carefully, which is helpful in preventing diabetes risk factors. High carbohydrate diets have negative effects on blood lipid levels as indicators of triglycerides, low-density cholesterol (LDL-c), high-density cholesterol (HDL-c) and glycated hemoglobin (HbA1c), the metabolism of glucose and they also increase insulin levels and thus resistance to insulin.Therefore, the diets also increase the risk of diabetes as well as cardiovascular diseases (Niknam and Esmailzadeh, 2012, Saneei and Esmaillzadeh, 2013, Shirani *et al.*, 2015).

Dietary carbohydrates are broken into simple and complex sugars, moreover; postprandial metabolic and hormonal responses are often different in complex and simple sugars. Therefore, carbohydrates are classified according to glucose postprandial responses, which are commonly classified in terms of glycemic index (GI) and glycemic load (GL). Moreover, GL and GI reflect the dietary carbohydrates and value of the eaten carbohydrates. The postprandial blood glucose levels and the insulin response are dependent on the quality as well as the quantity of carbohydrates intake (Atkinson *et al.*, 2008, Foster-Powell *et al.*, 2002). It has been reported during the past two decades that a low GI diet can improve the blood glucose control, lipid profile, and weight increase insulin sensitivity and reduce the effects of insulin resistance; while high GI diet increases the levels of blood glucose, insulin response, food intake, and risk of obesity. In general, most of foods with a low GI contain high amount of fiber, which protects the person against diabetes and cardiovascular diseases (Shirani *et al.*, 2015, Tsihlias *et al.*, 2000). A limited number of recent observational studies have shown that low GI or GL diet has a beneficial effect on metabolic risk factors of cardiovascular disease and T2D, including body mass index (BMI), cholesterol, HDL, HbA1c (Chiavaroli *et al.*, 2016, Min *et al.*, 2016, Niknam and Esmailzadeh, 2012, Shirani *et al.*, 2015).

It has been recommended in an epidemiological cohort study that dietary GI and GL are associated with diseases associated with insulin resistance. Furthermore, there is a positive association between the GI and GLand the development of the T2D (Mirmiran *et al.*, 2009, Thorup *et al.*, 2013).

Materials and Methods

Our article is a traditional review article. This review article was extracted by searching the creditable scientific databanks, including: PubMed, Embase, Science Direct, and Scopus using keywords such as GI, GL, diabetes and carbohydrate from the published literature. In this paper, a variety of studies, including

[DOR: 20.1001.1.24767417.2016.1.1.4.1]

prospective cohort, retrospective, case-control, and cross studies were studied from 2000 to 2016.The thematic relevance of the studies was assessed by investigating the title and summary of the article. The studies with the target group of animals, were not reviewed in this article. Finally, 25 articles with appropriate design, reliable and relevant information were selected and analyzed for this review article.

Results

In studies investigating the effect of dietary fiber and glycemic profile in diabetic patients, positive effects of high-fiber and low GI diets on blood glucose were observed. In a previous study in Canada which was similarly conducted on the evaluation of the effects of low GI and high fiber diets in patients with T2D, it was observed that the level of HbA1c was reduced by 18% in individuals who were under the influence of low GI and high fiber diet for 6 months (Jenkins *et al.*, 2008). In a study, conducted on 36787 Australian women aged from 40 to 69 years old with no history of diabetes, the relationship between the dietary GI and fiber-rich foods and risk of T2D were studied. The results of this study showed a reduction in GI diet to maintain the carbohydrate intake, which reduces the risk of T2D. To reduce the risk of diabetes, researchers recommended the use of bread with a low GI, instead of white bread and promotion of whole grain intake (Hodge *et al.*, 2004, Psaltopoulou *et al.*, 2010, Yanni *et al.*, 2016). Moreover, a review study in this respect states that following a low GI diet in patients with T2D and type 1 diabetes has short-term and long-term beneficial effects on controlling blood sugar. Since, high-fiber carbohydrate diets have necessarily low GI insulin shows lower responses and improves the lipid profiles after eating these types of diets (Riccardi *et al.*, 2008). The postprandial blood sugar levels determine the demand for insulin which depend on the quantity and quality of the ingested carbohydrate (Brand-Miller, 2004). In a prospective cohort study, an investigation was made on the consumption of dietary fiber from whole grains, fruits, vegetables and GI diet and the incidence of gestational diabetes (GDM) in a period of 8 years. The results showed that a 10 g/day increase in the dietary fiber reduces the risk of developing GDM by 26% and there is a positive relationship between the GI diet and the risk of GDM (Zhang *et al.*, 2006). The GI diet was also investigated in some studies, in which it was found that following this type of diet has positive effects on the prevention and treatment of diabetes. In a prospective study investigating the relationship between GI and diet and the GL of diet and risk of T2D, a total of 3075 elderly individuals were studied for 4 years, it was observed that the elderly with low GI diet are less likely to develop diabetes (Sahyoun *et al.*, 2008).

The results of a review study on the use of diets with a low GI in the management of diabetes control, showed that a low GI diet, in comparison with a normal or a high GI diet, improves blood sugar in people with diabetes by reducing HbA1c to the 0.43%. The study stated that foods with a low GI compared with conventional foods or high GI, have a small but clinically useful effect on medium-term control of blood glucose in patients with diabetes (Brand-Miller *et al.*, 2003). Moreover, another study showed that a low GI diet improves the insulin sensitivity and the blood glucose status by 60%. The results of this study over a period of 6 months showed that there is a significant positive relationship between dietary GI with the risk of diabetes in men and young women and those who had low physical activity and history of diabetes has been observed (Brand-Miller, 2004).

Furthermore, a prospective study was conducted in Iran to investigate the relationship between the GI and GL with the metabolic syndrome and its indicators. In this study, GL and GI were determined in people who were diagnosed with metabolic syndrome during the follow-up and were compared with people with no metabolic syndrome. The prevalence of metabolic syndrome was significantly higher in

[DOR: 20.1001.1.24767417.2016.1.1.4.1]

the highest GL and GI quintile compared with the lowest quintile after adjustment for lifestyle and dietary risk factors. On the other hand, the GI in the highest quintile was associated with an increase in the BMI, total cholesterol, low density lipoprotein cholesterol (LDL-c) and lower high density lipoprotein cholesterol (HDL-c) and the GL in the highest quintile were associated with an increase in the LDL-c and lower HDL-c. The results of this study show that the GI and GL can have adverse effects on the metabolic syndrome including diabetes (Mirmiran *et al.*, 2009). Moreover, in a prospective study in Europe, which investigated the relationship between a low GI diet and the effect of the traditional Mediterranean diet and the incidence of T2D on 22295 people, it was observed that the traditional Mediterranean diet decreased the incidence of T2D by 20% (Rossi *et al.*, 2013). Main results of these are presented in **Table 1**.

Table 1. Main results of studies

Author Year	No. of participants	Age (years)	Main results	Study duration
Rossi et al. 2013	22259	40-63	Low GI diet decreases the incidence of type 2 diabetes by 20%	11.34 years
Mirmiranet al. 2010	120	>40	GI and GL have adverse effects on the metabolic syndrome	6.4 years
Jenkins et al.2008	210	<60	low GI diet and high fiber diet reduces HbA1C by 18%	6 months
Sahyaun. et al. 2008	3075	70-79	low glycemic index die is related to low prevalence of diabetes in 4 years	4 years
Zhang et al. 2006	758	31	- 10 g /day increase in the dietary fiber reduces the risk of developing GDM by 26% - positive relationship between the GI and the risk of GDM	8 years
Allison et al. 2004	36787	40-69	low GI diet and high fiber diet reduces the risk of type 2 diabetes	4 years
Brand miller 2004	44	30-45	low GI diet improves the insulin sensitivity and the blood glucose status by 60%	6 months

Discussion

Many studies showed the inverse association between GI, GL, HDL-c level, and the direct relationship between the GI and GL of the dietary intake and reduced blood sugar (Niknam and Esmailzadeh, 2012, Saneei and Esmaillzadeh, 2013, Shirani *et al.*, 2015). Consumption of carbohydrates creates a range of different blood glucose levels and the insulin responses in people. The differences are affected by the quality and quantity of carbohydrates. Based on the previous studies, some types of carbohydrates increase both the risk of diabetes, cardiovascular diseases through fluctuations in blood glucose after meals, increasing insulin levels and levels of blood lipids (Niknam and Esmailzadeh, 2012, Saneei and Esmaillzadeh, 2013, Shirani *et al.*, 2015). The fluctuation in

[DOR: 20.1001.1.24767417.2016.1.1.4.1]

blood sugar levels, especially blood sugars 2 hours after eating is the risk factor, which increases the risk of cardiovascular diseases in non-diabetic persons. This problem also exists in people with diabetes. Moreover, high blood sugar and failure to control hyperglycemia and its resulting fluctuations play important role in the increased prevalence of cardiovascular diseases among people with diabetes. Since the high-fiber carbohydrate diet necessarily contains low GI, insulin shows lower responses and also improves lipid profiles after eating this type of diet (Krishnan *et al.*, 2007, Riccardi *et al.*, 2008, Salas-Salvadó *et al.*, 2011). Diets containing carbohydrate sources and high GI can lead to an increase in postprandial blood sugar and insulin. The hyper insulinemia can increase the risk of cardiovascular diseases by affecting the serum lipids, coagulation factors, inflammatory agents, endothelial function, and blood pressure (Ebrahimi *et al.*, 2008, Makino *et al.*, 2016, Shirani *et al.*, 2015).

The results of both studies are not consistent. The results of several randomized clinical trials have shown that there is no significant difference between a diet high in GI/GL and a low GI/GL diet in terms of their effect on glucose and insulin concentration and the insulin resistance (Brand-Miller *et al.*, 2003, Riccardi *et al.*, 2008). The results of the current studies on the effect of the type and amount of carbohydrate intake and GI, GI of the diet on the risk of T2D still remain controversial. But it is worth mentioning that the high-carbohydrate diet with a high GI and GL has negative effects on lipid metabolism and glucose in the body and can increase the risk of cardiovascular diseases and T2D.

Additionally, a diet with moderate fat, low saturated fats and carbohydrates low in GI and GL is another factor which plays a major role in the management and prevention of cardiovascular diseases and T2D. A simple and cost-effective way to reduce the disease complications and its related mortality is to investigate the effects of diet on the causes of T2D. In this way, nutrition expert and physicians can easily control the serum glucose and HbA1c levels that are strong predictors of diabetes by adopting appropriate nutritional and dietary decisions and consulting on the proper dietary pattern and nutritional intervention. Considering the fact that the forms and glycemic nature of carbohydrates can increase the risk of diabetes and exacerbate its complications, it is necessary to conduct study and research in this area (Atkinson *et al.*, 2008, Shirani *et al.*, 2015).

Acknowledgments

This article is drawn from the research project. Hereby, the authorities of Jundishapur University of Medical Sciences are appreciated for approving and funding this project.

Author contributions

Zeinali F, Asadi Samani H, Toupchian O, Abdollahi S, Samadi M wrote the paper. Samadi M is responsible for all parts of the manuscript. All authors read and approved the final manuscript.

Conflicts of Interest

The authors of this paper have no conflicts of interest to disclose.

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[DOR: 20.1001.1.24767417.2016.1.1.4.1]

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[DOR: 20.1001.1.24767417.2016.1.1.4.1]