What Should be the Ideal Carbohydrate Intake in Type 1 Diabetes?: A Literature Review

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Abstract

The purpose of this literature review is to assess the impact of carbohydrate intake through diet on postprandial glycemia for individuals with type 1 diabetes and to provide insight into the recommended carbohydrate intake outlined in national and international guidelines by determining ideal intake quantities. A literature search and standard data extraction were conducted using Google Scholar, PubMed, and Web of Science Databases. The literature review spanned from January to June 2023. Given the limited number of studies involving individuals with type 1 diabetes, a total of 7 research articles were thoroughly examined. While both long-term and short-term studies have investigated high- and low-carbohydrate diets in type 1 diabetes, only one study design was found that explored the effects of closely related ratios (comparing 45% to 50%) on postprandial glycemia. Although many studies have primarily concentrated on low-carb diets, there exists a gap in the scientific literature despite some evidence indicating potential glycemic improvements in individuals with type 1 diabetes on such diets. It's noted that adopting such a diet might elevate the risk of cardiovascular diseases in the long run and potentially hinder growth, particularly in children. This literature review has identified various interventions with positive impacts on glycemic control for different levels of carbohydrate intake. General recommendations from guidelines developed for individuals with type 1 diabetes suggest that 50% of total energy intake should come from carbohydrates, with a preference for complex carbohydrate sources.

Keywords: Type 1 diabetes, carbohydrate intake, postprandial glycemia.

Tip 1 Diyabette İdeal Karbonhidrat Alımı Ne Olmalıdır?: Literatür Taraması

Öz

Bu literatür taramasının amacı, tip 1 diyabetli bireylerde diyette karbonhidrat alımının postprandiyal glisemi üzerindeki etkisini değerlendirmek ve ideal alım miktarlarını belirleyerek ulusal ve uluslararası kılavuzlarda belirtilen önerilen karbonhidrat alımına ilişkin fikir sağlamaktır. Google Akademik, PubMed ve Web of Science veritabanları kullanılarak literatür taraması yapılmıştır. Literatür taraması Ocak-Haziran 2023 dönemini kapsamaktaydı. Tip 1 diyabetli bireyleri kapsayan sınırlı sayıdaki çalışma göz önüne alındığında, toplam 7 araştırma makalesi kapsamlı bir şekilde incelenmiştir. Hem uzun süreli hem de kısa süreli çalışmalar tip 1 diyabette yüksek ve düşük karbonhidratlı diyetleri araştırırken, yakın oranların (%45 ila %50'yi karşılaştıran) postprandiyal glisemi üzerindeki etkilerini araştıran yalnızca bir çalışma tasarımı bulunmuştur. Pek çok çalışma öncelikle düşük karbonhidratlı diyetler üzerine yoğunlaşmış olsa da, bu tür diyetler uygulayan tip 1 diyabetli bireylerde potansiyel glisemik iyileşmeler olduğunu gösteren bazı kanıtlara rağmen bilimsel literatürde bir boşluk bulunmaktadır. Bu diyetlerin benimsenmesinin uzun vadede kardiyovasküler hastalık riskini artırabileceği ve özellikle çocuklarda büyümeyi engelleyebileceği belirtilmektedir. Bu literatür incelemesi, farklı karbonhidrat alımı seviyeleri için glisemik kontrol üzerinde olumlu etkileri olan çeşitli müdahaleleri tanımlamıştır. Tip 1 diyabetli bireyler için geliştirilen kılavuzlardaki genel öneriler, toplam enerji alımının %50'sinin karbonhidratlardan gelmesi gerektiğini ve kompleks karbonhidrat kaynaklarının tercih edilmesini önermektedir.

Anahtar Sözcükler: Tip 1 diyabet, karbonhidratlı alımı, postprandial glisemi.

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Introduction

Type 1 diabetes (T1D) is a group of metabolic diseases characterized by insulin deficiency resulting from autoimmune destruction of β-cells and the consequent development of hyperglycemia. Although T1D is classified as having a young onset, the disease can manifest at any age, and up to 50% of cases emerge during adulthood[1]. According to the International Diabetes Federation (IDF) 2021 report, it is projected that approximately 537 million individuals worldwide have diabetes, and if the current trend continues, it is estimated that by the year 2045, there will be 784 million individuals aged 20-79 with diabetes[2].

In individuals with T1D carbohydrates are the primary determinant of postprandial glycemic response[3]. For individuals with diabetes, achieving and maintaining health and optimal glycemic control require balanced nutrient intake, managing carbohydrate load, reducing glycemic index, and establishing a healthy eating pattern[4]. Providing 45-50% of daily energy from carbohydrates demonstrates the ability to achieve optimal postprandial glycemic control[5]. Carbohydrate intake should include high-fiber and minimally processed, quality carbohydrate sources. Meal plans should consist of non-starchy vegetables, minimal added sugar, fruits, and whole grain products[6].

Material and Methods

For this literature review, a search of the relevant literature was conducted in the Google Scholar and PubMed, Web of Science Databases. A literature review was conducted between January and June 2023 for the study. The descriptors used for the search were as follows, in accordance with the MeSH index: "type 1 diabetes mellitus", "dietary carbohydrates intake" and "carbohydrates rate". The study included literature review, case reports and clinical studies. Studies between the years 2011-2023 are included.Studies were filtered for relevance. Studies were excluded if the results were not relevant to the subject of the review or were clearly of low quality. The final review includes seven articles and twenty-five referenced articles. Important conclusions or conclusions were drawn from each of these articles.

Strengths of Review

Low-carbohydrate diets have been investigated in the treatment of T1D up to this day. The main strength of the current review lies in the inclusion of studies comparing the effects of diets such as 50% carbohydrate intake or the Mediterranean diet to low-carbohydrate diets on postprandial glycemia. This approach will be beneficial in evaluating the optimal carbohydrate intake, considering national dietary guidelines in our study.

Recommended Carbohydrate Ratios in Guidelines

Recommendations regarding carbohydrate intake have significantly varied over the years, ranging from 40% (Joslin Diabetes Center) to 60% (Diabetes and Nutrition Study Group of EASD and Diabetes Association in the UK). Since 2008, ADA guidelines have not specified a particular percentage range for carbohydrate and other macro-nutrient intake. It wasn't until 2014 that ADA's consensus statement proposed that there isn't an

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ideal macro-nutrient composition for diets targeting diabetic patients and that there is no optimal carbohydrate amount in a diabetes diet plan[7].

Table 1. Recommended carbohydrate ratios in guidelines for type 1 diabetes [5,6,8-10]

ISPAD,2018	ADA,2021	DDTR, 2021	TUBER, 2022	Diabetes Canada, 2022
50-55% carbohydrates (average intake of 150 g/day for children aged 1.5-3 years; 200 g/day for children aged 4-10 years)	The ratio is not specified. High fiber and unprocessed carbohydrate intake are recommended (Level B evidence).	45-65 % (least 130 g)	45-60 %	≥ 45 %

ISPAD: International Society for Pediatric and Adolescent Diabetes, ADA: American Diabetes Association, DDTR: Diabetes Diagnosis and Treatment Recommendations, TUBER: Turkey Nutrition Guidelines

When examining guidelines aimed at children, the National Institute for Health and Care Excellence recommends that energy intake should be derived from approximately 50-55% carbohydrates, less than 35% fats, and 15-20% proteins[11]. National guidelines of Australia and Canada for individuals with diabetes recommend that at least 45% of daily energy intake should come from carbohydrates in the diet[10,12]. The carbohydrate intake recommended by the Nutrition Associations of Germany, Austria, and Switzerland ranges from 56% to 90%. However, studies on dietary intake of individuals with diabetes indicate a discrepancy between recommended and reported intakes, with this gap increasing significantly with age. It is noted that particularly adolescent individuals with diabetes have carbohydrate intakes below the recommended levels[13,14]. Similarly, the evidence-based practice guidelines of the Japan Diabetes Society recommend that 50-60% of energy should come from carbohydrates and highlight that carbohydrate intake levels for individuals with diabetes range from 40% to 60%[15].

Discussion

In recent years, diets with different carbohydrate ratios and contents are being clinically tested for their impact on postprandial glycemia. In this review, it has been determined that a low-carbohydrate diet leads to clinically more significant reductions in blood glucose levels compared to high and 50% carbohydrate intake. However, it has also been observed that ketone bodies could lead to increases in blood lipid levels (Table 2). In a study conducted in Japan with individuals with T1D, it was determined that patients who consumed less than 50% of their total energy from carbohydrates spent less time in postprandial hyperglycemia and more time in hyperglycemia[16]. Low-carbohydrate diets are often tested (Table 2). The most controversial aspect of low-carbohydrate diets is their potential to increase the risk of cardiovascular disease due to higher total and saturated fat intakes[17]. In adults following very low-carbohydrate diets, it has been found that there are higher saturated fat intakes (daily fat intake of 39% ± 11%)[18]. Furthermore, among the risks associated with low-carbohydrate diets are ketoacidosis, hypoglycemic unawareness due to ketosis, impaired adrenal response after hypoglycemia, growth retardation, and long-term cardiometabolic risks. However, there are studies indicating that short stature is highly correlated with HbA1c levels and that HbA1c serves as one of

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the strongest determinants of cardiovascular diseases[19]. Low-carbohydrate, high-fat diets can result in lower energy intake than recommended. Due to restrictions in food groups, deficiencies in fiber, thiamine, vitamin B6, and iodine are possible[20]. Very low-carbohydrate diets are also believed to cause ketoacidosis, encourage urinary calcium loss, and lead to low bone mineral density, increasing the risk of osteoporosis[17]. While there are few studies on this topic, an animal study demonstrated that low-carbohydrate diets induced low bone mineral density in rats[20].

Table 2. Diets with different carbohydrate contents and clinical outcomes

Study details	**Population**	**Intervention**	**Results**
Levran et al., Israel, prospective intervention clinical trial (2023)[21]	T1D, 20 adolescents	LCD; 50-80 g/day, 12 weeks	HbA1c level decreased from 8.1% (7.5; 9.4) to 7.7% (6.9; 8.2) (p = 0.021). Adolescents showed reductions in BMI z-score (p = 0.019) and waist circumference (p = 0.007)
Issaksson et al., Sweden, Randomized-cross-over (2023)[22]	T1D and inadequate glycemic control (HbA1c>= 7.5%), 54 adults	Moderate carbohydrate diet (30% total energy from carbohydrates) Traditional diabetes diet (50% total energy from carbohydrates), 4 weeks	Design of a randomized cross-over study
Dimosthenopoulos ve ark., Athens, Randomized- clinical trial (2021)[7]	T1D, 15 individuals	**Three different/isocaloric diet** High-protein/low carbohydrate (20%) Mediterranean/low glycaemic index (40%) carbohydrates, 50% carbohydrates, 4 weeks	Euglycaemic range was not statistically different between HPD, MED and REF (p = 0.105). During the HPD period, 11 out of 15 participants spent more time within euglycameic compared with either the REF or MED.
Ranjan et al., Denmark, randomized controlled (2017)[23]	T1D, 10 individuals	LCD; ≤50 g/day HCD; ≥250 g/day, 1 weeks	Compared to HCD on LCD, the ratio of the duration with blood sugar concentration between 3.9-10.0 mmol/L is higher (83% ± 9% ve72%±11%; p = 0,02). In LCD, ketone bodies and free fatty acid levels
Schmidt et al., Denmark, randomized controlled (2019)[24]	T1D,14 individuals	LCD; ≤100 g/day, HCD; ≥250 g/day, 12 weeks	The duration spent in the range of 3.9-10.0 mmol/L did not differ significantly between the groups (LCD 68.6 ± 8.9% and HCD 65.3 ± 6.5%, p = 0.316). In the LCD diet, the time spent <3.9 mmol/L was lower (1.9% vs. 3.6%, p <0.001), and glycemic variability was lower (32.7% vs. 37.5%, p = 0.013). Severe hypoglycemia was not reported in either of the diets.
Krebs et al., New Zeland, randomized controlled (2016)[25]	T1D,10 individuals	The standard diet Low carbohydrates (50-75 g), 12 weeks	In the LCD group, there were significant reductions in HbA1c (from 63 to 55 mmol/mol or 8.9% to 8.2%,

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			p<0.05) and daily insulin usage (from 64.4 to 44.2 units/day, *p*<0.05). No changes have been observed in the blood lipid profile.
Leow et al., Australia, randomized controlled trial (2018)[18]	T1D 11 individuals	<55 g/day of carbohydrates, 1.5 years	Participants spent 74±20% of their time in the glycemic range (4-8 mmol/l) and 3±8% in the hyperglycemic (>10 mmol/l) range. Among the participants, total cholesterol, LDL cholesterol, total cholesterol/HDL cholesterol ratio, and triglycerides were within the recommended range in 82%, 82%, 64%, and 27% respectively.

* *LCD: Low Carbohydrate Diet HCD: High Carbohydrate Diet VLCD: Very Low Carbohydrate Diet HDL: High-Density Lipoprotein LDL: Low-Density Lipoprotein HPD: High-Protein/Low-Carbohydrate Diet MED: Mediterranean Diet REF: Reference Diet*

Conclusion

While there have been long-term and short-term studies examining high and low carbohydrate diets in T1D, only one study investigating the effects of close ratios (comparing 45% to 50%) on postprandial glycemia has been identified. Despite some evidence suggesting that a low-carbohydrate diet could improve glycemia in diabetic individuals, there is a scientific literature gap. It's noted that in the long term, such a diet could increase cardiovascular disease risk and particularly lead to growth retardation in children.

As a general conclusion drawn from guidelines and clinical studies, the recommended ratio for individuals with T1D is for 50% of total energy intake to come from carbohydrates.

Author's Contributions

BB: Conceptualization, Research, Data curation, Project administration, Writing – review and editing. **VO:** Research, Data Curation, Project administration, Writing – review and editing.

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