# Assessment of Carbohydrate Content Estimation among Adolescents with Type 1 Diabetes and their Glycemic Control

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**Abstract**

**Background:** Carbohydrate content estimation is one of the techniques in diet management that can provide flexibility in choosing food and can help adolescents with type 1 diabetes mellitus (T1DM) to identify blood glucose patterns. Dietary regulation, especially monitoring of carbohydrate intake, is the main determinant of post-meal blood glucose in T1DM. **Aim:** The aim of this study was to assess the effect of carbohydrate content estimation among adolescents with type 1 diabetes on their glycemic control. **Research Question:** What is the relation between carbohydrate content estimation among adolescents with type 1 diabetes and their glycemic control?. **Setting:** The study was conducted in the outpatient Children's Diabetes Clinic, Children's Hospital, Ain Shams University. **Subjects:** A sample of 81 adolescents with type 1 diabetes between 12-18 years of age. **Data collection tools:** 1) Diabetic adolescent assessment sheet (by interview) included the studied adolescents' characteristics, diabetes history and physiological assessment, 2) Ped Carb Quiz (PCQ) to assess the studied adolescents' carbohydrate recognition and insulin dosing accordingly**. Results:** The results of this study revealed that less than two thirds had been previously hospitalized due to DKA, half of them had HbA1c 8 - <10 % with mean HbA1c 9.7 ± 2.343% and total PCQ score mean$\bar{X}$±SD was 32.03±10.34. **Conclusion:** It could be concluded that adolescents with type 1 diabetes had a low level of recognition of carbohydrate content estimation and there was a non-significant correlation between glycemic control and their total PCQ score. **Recommendation:** Enhance the awareness of the adolescents with type 1 diabetes about carbohydrate content estimation.

**Keywords:** Adolescents type 1 diabetes, Carbohydrate Content Estimation, Nursing.

## Introduction

Type 1 Diabetes Mellitus (T1DM) is a chronic illness characterized by the body's inability to produce enough insulin because of the autoimmune destruction of the β cells of the pancreas. Onset often occurs in childhood, but the disease can also develop in adults (in their late 30s and early 40s). T1DM results from the interaction of genetic and environmental factors that alter the immune system and culminate in the destruction of the pancreatic β cell ***(Rogers et al., 2017).***

According to the International Diabetes Federation "IDF", 8.8% of the adult population worldwide has diabetes. Of all individuals with diabetes, only 10-15% have T1DM. T1DM is the most common form of diabetes in children less than 15 years of age. Globally, T1DM prevalence is around 1.1 million individuals and this figure has been rising by 3% annually ***(International Diabetes Federation, 2019).***

Despite the advances in technology and medical treatment, nutritional therapy continues to be a cornerstone of diabetes care. Nutritional recommendations for a healthy lifestyle for the non-adolescents with type 1 diabetes are also appropriate for adolescents with T1DM, with the only difference compared to healthy peers being the need for insulin therapy. ***(Smart et al., 2014).***

Nutrition has a major effect on blood glucose levels. Adolescents with T1DM need to understand the effect of food on their blood glucose and plan meals accordingly. Adolescents with type 1 diabetes should be referred for individualized medical nutrition

therapy provided by a registered dietitian who is knowledgeable and skilled in providing diabetes-specific nutritional advice in conjunction with the diabetes technology being used ***(Evert et al., 2019).***

Carbohydrate counting is one of the techniques in diet management that can provide flexibility in choosing food and can help adolescents with type 1 diabetes to identify blood glucose patterns. Dietary regulation, especially monitoring of carbohydrate intake, is the main determinant of post-meal blood glucose in T1DM ***(Heryanda et al., 2020) .***

The primary goal in the management of diabetes is to achieve as near normal regulation of blood glucose (postprandial and fasting) as possible. The total amount of carbohydrate consumed has the strongest influence on glycemic response. Typically, distribution of energy sources recommended is 50-55 % carbohydrate, 35 % fats, and 10-15 % protein. A commonly used prescribed meal plan consists of 20 % of calories at breakfast, 30 % at launch and 30 % at dinner with 2 snacks of 10 % at bed time all over the day to avoid nocturnal hypoglycemia ***(Liu et al., 2017).***

The stages in simple carbohydrate counting suggested by dietitians or nutritionists include, determining or choosing healthy foods with various types of vegetables, limiting fat and paying attention to food portion sizes, focusing on the number of servings of carbohydrates from the food consumed, determine the target number of carbohydrates in grams to be consumed by monitoring and consulting with a dietitian or nutritionist, recording portion sizes of food and drinks consume throughout the day, monitoring blood glucose levels regularly and periodically ***(Canadian Diabetic Association, 2020).***

According to ISPAD, the adolescent with type 1 diabetes should be advised regarding meal planning, content and the timing of snacks or meals in the context of each adolescent's individual circumstances, lifestyle and the insulin action profile. Education should include behavior change approaches, motivational interviewing and counseling and should be regularly reviewed to meet the changing needs and requirements of the developing adolescent ***(Franz et al., 2017).***

There are many reasons why adolescents do not adhere or adhere inconsistently and incompletely with a diabetic treatment regimen, including psychological changes related to adolescence (stubbornness and desire for independence, resistance to advices, rebellion), financial constraints, cultural barriers, language barriers, literacy, educational barriers, family constraints or responsibilities, poor availability of or inconvenient access to healthcare resources, misconceptions and fears about the benefits and risks of diabetic treatments, misconceptions about diabetes, and lack of family, social, or professional support ***(ADA, 2020).***

## Significance of the study:

Adolescence is a stage of searching independence, increasing activity and increasing food flexibility. Furthermore, most parents work away from home and cannot follow teenagers in their daily activities. Currently, little quantitative knowledge is available regarding the accuracy of carbohydrate content estimation and the impact of carbohydrate counting errors ***(Reiterer & Freckmann, 2019).***

Assessment of adolescents with type 1 diabetes awareness regarding carbohydrate content estimation and its effect on blood glucose levels could help in applying a balanced nutritional plan that prevents the incidence of complications such as hypoglycemia, hyper-glycemia , which are either due to having large insulin doses relative to the amount of calories consumed or eating large amounts of food relative to insulin doses.

## Aim of the Study:

This study aims to assess the effect of carbohydrate content estimation among adolescents with type 1 diabetes on their glycemic control.

**Research question:**

What is the relation between carbohydrate content estimation among adolescents with type 1 diabetes and their glycemic control?.

**Subjects and Methods**

**Technical Design:**

**Research Design:**

A descriptive explanatory design was used to conduct this study.

**Research Setting:**

The study was conducted in outpatient Children's Diabetes Clinic, Children's Hospital, Ain Shams University. The clinic is located in the 4th floor consisting of 2 rooms working from Monday to Wednesday from 9 Am till 1 PM.

**Subjects:**

Our sample included 81 adolescents with type 1 diabetes. Using EPI Info 7 program for sample size calculation with margin of error = 10 % and at 95 % confident level, a sample size of 81 adolescents with type 1 diabetes was needed ***(Community, Environmental and Occupational Medicine Department, Faculty of Medicine, Ain Shams University).***

**Tools for data collection:**

Data were collected using the following tools:

**Tool I: Adolescents assessment sheet (by interview):** It was designed by the researcher in an Arabic language based on recent and relevant literatures and studies to assess the data in the following parts :

**Part 1: Adolescents' characteristics:** It was concerned with adolescents with type 1 diabetes characteristics (age, gender, and their educational level).

**Part 2: History ofdiabetes:** It was concerned with past and present medical history including duration of diabetes, presentation at diagnosis, type of treatment, previous follow up with a nutritionist, history of complications, history of hospitalization and family history of diabetes.

**Part 3: Physiological characteristics of adolescents:** It was concerned with assessment of blood glucose levels including pre-prandial and post-prandial blood glucose levels, and glycated hemoglobin (HbA1c).

The pre-prandial blood glucose was categorized into three levels; low level if pre-prandial blood glucose is less than 80 mg/dL, normal level if pre-prandial blood glucose is equal or more than 80 mg/dL and less than 130 mg/dL and high level if pre-prandial blood glucose is equal or more than 130 mg/dL. Meanwhile, the post-prandial blood glucose was categorized into two levels; normal level if post-prandial blood glucose is less than 180 mg/dL and high level if post-prandial blood glucose is more than or equal 180 mg/dl ***(ADA, 2022).***

Concerning the Glycated Hemoglobin "HbA1C" it was categorized into four levels; normal level for diabetics if HbA1C is more than 6% and less than 7%, moderate level if HbA1C is equal or more than 7% and less than 8%, high level if HbA1C is equal or more than 8% and less than 9% and very high level if HbA1C is equal or more than 10% ***(Patra, 2022).***

**Tool II: Ped Carb Quiz (PCQ):** This tool was adopted from The American Diabetes Association (2010) to assess seven domains; four carbohydrate recognition domains and three insulin-dosing domains for adolescents with type 1 diabetes ***(Koontz et al., 2010)***.

The Four carbohydrate recognition domains include; first is recognition of carbohydrates, second is carbohydrate counting in individual food items, third is carbohydrate counting in whole meals, while fourth is nutrition label reading. The three insulin dosing domain include three sub-domains; first, is use of insulin dose correction based on blood glucose level, second is use of insulin-to-carbohydrate ratio in insulin dosing, while third is calculation of whole meal insulin dose.

**Scoring system**

The PCQ scoring instructions by ADA was for each correctly answered item

contributed one point to total score. Partial credit (1⁄2 point) was awarded for answers close to the correct answer. Zero point was awarded for incorrect answers. For the questions with multiple parts; each part was considered one item and contributes one point to the total score if answered correctly.

The final PCQ is a 78-item, the maximum overall obtainable score was 78/78, with a maximum score of 58/78 in the carbohydrate recognition domain and 20/78 in the insulin dosing domain. Higher scores indicate greater degree of recognition about carbohydrates and insulin-dosing ability.

Maximum score for the carbohydrate recognition domains is 58 distributed over 1 point for each sub-item; first, recognition of carbohydrates maximum score is 36, second, carbohydrate counting in individual food items maximum score is 6, third, carbohydrate counting in whole meals maximum score is 8, while nutrition label reading maximum score is 8.

Maximum score for insulin dosing domain is 20 distributed over 1 point for each sub-item; first, insulin dose correction based on blood glucose level maximum score is 6, second, use of insulin-to-carbohydrate ratio in insulin dosing maximum score is 6, while calculation of whole meal insulin dose maximum score is 8.

**Operational design:**

The operational design of this study included preparatory phase, validity and reliability of the developed tools, pilot study, field work, and ethical consideration.

**Preparatory phase:**

It included reviewing the recent and related literature covering various aspects of the study problem using text books, articles, magazines, periodicals and web sites in order to develop tools for data collection.

**Tools validity:**

To achieve the criteria of trust worthiness of data collection tools in this study, the tools were tested and evaluated for their face and content validity. Face and content validity are tested by experts in Pediatric Nursing department in Faculty of Nursing Ain Shams University, to ascertain relevance, clarity and completeness of the tools, experts elicited responses were either agree or disagree or agree with modifications for the face validity. The developed tools were modified according to the experts' opinions. These modifications were in the form of omission or addition of some questions or rephrasing of other statements.

**Reliability:**

The reliability was conducted by using Alpha Chronbach Test to measure the internal consistency of the tool used in the current study. The internal consistency was measured to identify the extent to which the items of the tool measure the same concepts and correlate with each other. For reliability test-retest was done (0.84).

The Alpha Cronbach for Ped Carb Quiz was 0.88 for the whole test and ranged from 0.38 to 0.86 for individual domains: recognition of carbohydrates, 0.86; carbohydrate counting in individual food items, 0.38 carbohydrate counting in whole meals, 0.49 nutrition label reading, 0.66 use of insulin dose correction based on blood glucose level, 0.82 use of insulin-to-carbohydrate ratio in insulin dosing, 0.78 and calculation of whole meal insulin dose domains, 0.77.

**Pilot study:**

A pilot study was conducted on 8 adolescents with type 1 diabetes (10 % of total sample) during their visits in the diabetes clinic to ensure the clarity and simplicity of the study questions, applicability of the study and the time needed to fill in the questionnaires. The necessary modification in form of omission or addition of some questions or rephrasing of other statements was carried out as revealed from the pilot study. A few modifications were done after the pilot study and those pediatric patients who were included in the pilot study were excluded from the actual study sample.

**Ethical consideration:**

Ethical approval was obtained from The Research Scientific Ethical Committee of faculty of nursing, Ain Shams University. In addition, oral approval was obtained from every participant who agreed to share in the study. The study subjects were assured that all the gathered data will be used for the research purpose only. They were assured that anonymity and confidentiality would be guaranteed and the right to withdraw from the study at any time. Ethics, values, culture and beliefs were respected.

**Field work:**

The actual field work of the data collection process was done in a period of six months; started from the January 2022 till July 2022. Data were collected from adolescents during follow up with physicians at the clinic on Tuesdays and Wednesdays "fixed scheduled time for diabetic clinic" during AM shifts.

Each study subject was individually interviewed by the researcher usually during waiting time for the clinic after arrangement with the assigned physician using the previously mentioned tools, where aim and expected outcomes of the study were clearly stated.

The study subjects were assessed for their characteristics, past and present medical and family history which was reported by the adolescent himself, his/her parents or from their medical records using tool I. The past and present medical history was concerned with duration of diabetes, presentation at diagnosis, type of treatment, previous follow up with a nutritionist, history of complications and history of hospitalization and family history of diabetes.

Physiological data (glycemic control) was assessed by reviewing the self-documented readings done by the adolescents of blood glucose levels "pre-prandial, and post-prandial either were hand written in a blood glucose monitoring log or recorded on their blood glucose monitoring device during scheduled follow up with the physician in the clinic. The HbA1C was assessed through asking the adolescents about the last result of HbA1C.

The assessment of adolescents with type 1 diabetes carbohydrate content estimation was done by using Ped Carb Quiz "tool II".

**Administrative design:**

An official approval explaining the aim of the study was issued from the Dean of Faculty of Nursing, Ain Shams University to the Directors of Children's Diabetes Clinic, Children's Hospital, Ain Shams University in order to obtain permission and cooperation to carry out the study.

**Statistical design:**

The collected data were organized, coded and analyzed by using appropriate statistical significant tests. The statistical analysis of data was done by using the Statistical Package for Social Science (SPSS), version 20.0 (SPSS Inc., Chicago, Illinois, USA). Quantitative data were expressed as mean ± standard deviation. Qualitative data were expressed as frequency and percentage. A p value <0.05 was considered significant.

## Results

**Table (1)** shows that nearly half (46.9%) of the adolescents with type 1 diabetes were at the age between 14<16 years (X̄±SD 14 ± 1.849 years), 67.7% were females and almost one third (34.6%) of them were studying at preparatory school.

**Table (2)** illustrates that more than one third (41 %) of the adolescents with type 1 diabetes had more than 6 years duration of the disease (X̄ ±SD 6.073 ± 4.172 year), half of them (50.6 %) presented with hyperglycemic symptoms at diagnosis, almost half of them (49.4 %) had previous hospitalization, almost two thirds (65 %) had been previously hospitalized due to DKA

**Figure (1)** reveals that the majority (90%) of the adolescents with type 1 diabetes never follow up with a nutritionist.

**Table (3)** illustrates that 84%, and 69.2 % of the adolescents with type 1 diabetes had pre-prandial blood glucose level ≥130 mg/dL, and post-prandial blood glucose level > 180 mg/dL respectively and 48.3 % of them had HbA1C 8 - <10 % (X̄ ±SD 9.7 ± 2.343%).

**Table (4)**shows that the mean score of carbohydrate recognition was 57.2±11.91, for carbohydrate counting in an individual item was 22.84±13.55, for nutritional label reading the mean score was 7.56±11.97 and for

carbohydrate counting in a whole meal was 22.53±11.43. Meanwhile, the total mean score was 42.02±10.33 for carbohydrate recognition domain.

**Table (5)** shows that the mean score for using of insulin dose correction was 21.81±10.75, use of insulin to carbohydrate ratio was 24.49±14.21 and calculation of whole meal insulin dose was 20.37±10.16. Meanwhile, the total mean score was 22.04±9.35 for the insulin dosing domain.

**Table (6)** illustrates that the total mean score for carbohydrate recognition domain was 42.02±10.33, for insulin dosing domain was 22.04±9.35 and for total PCQ score was 32.03±10.34.

**Table (7)** reveals that there was a non-significant correlation between adolescents with type 1 diabetes glycemic control and total PCQ score with p-value >0.05.

**Table (1): Demographic characteristics of the adolescents with type 1 diabetes (n=81).**

| Adolescents' characteristics | No. | % |
|---|---|---|
| **Age (years)** | | |
| • 12 : <14 | 32 | 39.5 |
| • 14 : <16 | **38** | **46.9** |
| • 16 : ≤18 | 11 | 13.6 |
| X̄±SD : 14 ± 1.849 | | |
| **Gender** | | |
| • Male | 27 | 33.3 |
| • Female | **54** | **67.7** |
| **Level of education** | | |
| • Primary | 28 | 34.6 |
| • Preparatory | **28** | **34.6** |
| • Secondary | 25 | 30.8 |

**Table (2): Distribution of the adolescents with type 1 diabetes according to their medical diabetes history (n=81).**

| Medical history | No. | % |
|---|---|---|
| **Duration of Diabetes (years) mean±SD** | 6.073 ± 4.172 | ---------- |
| • < 3 | 23 | 28 |
| • 3: ≤ 6 | 25 | 31 |
| • > 6 | **33** | **41** |
| X̄±SD: 6.073 ± 4.172 | | |
| **Presentation at diagnosis** | | |
| • Coma | 37 | 45.7 |
| • Asymptomatic, during investigation for another disease | 3 | 3.7 |
| • Hyperglycemia symptoms | **41** | **50.6** |
| **Type of treatment** | | |
| • Insulin | 76 | 93.8 |
| • Insulin and nutritional therapy | 5 | 6.2 |
| **History of hospitalization** | | |
| • **Yes** | **40** | **49.4** |
| • No | 41 | 50.6 |
| **Reason for hospitalization (n=40)** | | |
| • DKA | **26** | **65.0** |
| • Hypoglycemia | 7 | 17.5 |
| • Glycemic Coma | 7 | 17.5 |
| **Previous family history of DM** | | |
| • Yes | **64** | **79.0** |
| • No | 17 | 21.0 |

**Figure (1): Distribution of the adolescents with type 1 diabetes according to their Follow up with nutritionist (n=81).**

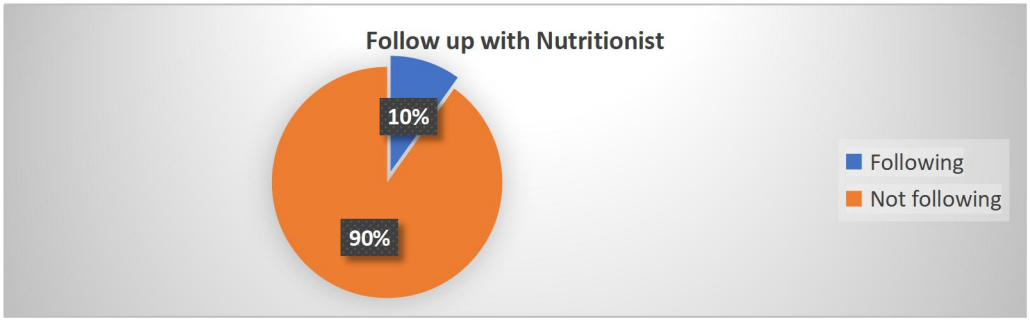


**Table (3): Distribution of the adolescents with type 1 diabetes according to their glycemic assessment (n=81).**

| Adolescents glycemic assessment | No. | % |
|---|---|---|
| **Pre-prandial blood glucose** | | |
| • < 80 mg/dL | 1 | 1.2 |
| • 80 - < 130 mg/dL | 12 | 14.8 |
| • ≥130 mg/dL | **68** | **84** |
| **Post-prandial blood glucose** | | |
| • ≤ 180 mg/dL | 25 | 30.8 |
| • > 180 mg/dL | **56** | **69.2** |
| **Glycated hemoglobin (HbA1C)** | | |
| • Not done | 3 | 3.7 |
| • < 6% | 1 | 1.3 |
| • 6 - < 8% | 14 | 17.4 |
| • 8 - <10% | **39** | **48.3** |
| • ≥ 10% | 24 | 29.3 |
| X̄ ±SD : 9.7 ± 2.343 | | |

**Table (4): Mean score of carbohydrate recognition domain among the studies adolescents with type 1 diabetes (n=81).**

| Carbohydrate recognition domain | X̄ ±SD |
|---|---|
| Carbohydrate recognition | 57.2 ± 11.91 |
| Carbohydrate counting in an individual item | 22.84 ± 13.55 |
| Nutritional label reading | 7.56 ± 11.97 |
| Carbohydrate counting in a whole meal | 22.53 ± 11.43 |
| Total score | 42.02 ± 10.33 |

**Table (5): Mean score of insulin dosing domain among the studied adolescents with type 1 diabetes (n=81).**

| Insulin dosing domain | X̄ ±SD |
|---|---|
| Use of insulin dose correction | 21.81 ± 10.75 |
| Use of insulin to carbohydrate ratio | 24.49 ± 14.21 |
| Calculation of whole meal insulin dose | 20.37 ± 10.16 |
| Total score | 22.04 ± 9.35 |

**Table (6): Mean score of total PCQ score among the studied adolescents with type 1 diabetes (n=81).**

| Total PCQ score | X̄ ±SD |
|---|---|
| Carbohydrate recognition domain | 42.02 ± 10.33 |
| Insulin dosing domain | 22.04 ± 9.35 |
| Total score | 32.03 ± 9.34 |

**Table (7): Correlation between parameters of glycemic control and total PCQ score among the studied adolescents with type 1 diabetes (n=81).**

| Parameters of glycemic control | Total PCQ score | |
|---|---|---|
| | r-value | p-value |
| Pre-prandial blood glucose | -0.057 | 0.611 |
| Post-prandial blood glucose | -0.160 | 0.152 |
| Random Blood Sugar | -0.066 | 0.555 |
| HbA1C | -0.064 | 0.575 |

*r-Pearson Correlation Coefficient; p-value >0.05 is insignificant; *p-value <0.05 significant correlation; **p-value <0.001 highly significant.*

## Discussion

chronic rise in the blood glucose level (hyperglycemia) causes morbidity, and mortality. Type 1 diabetes mellitus is caused by lack of adequate insulin production by pancreas ***(National Institute of Diabetes and Digestive and Kidney Diseases, 2021).***

Carbohydrate content estimation is one of the techniques in diet management that can provide flexibility in choosing food and can help adolescents with type 1 diabetes to identify blood glucose patterns. Dietary regulation, especially monitoring of carbohydrate intake, is the main determinant of post-meal blood glucose in T1DM ***(Heryanda et al., 2020).***

This study aimed to assess the effect of carbohydrate content estimation among adolescents with Type 1 Diabetes on their glycemic control.

Regarding the characteristics of the studied adolescents with type 1 diabetes, the finding of the present study showed that nearly half of them were at the age between 14<16 years ($\bar{X}$±SD 14 ± 1.849 years) and more than two thirds were females. These findings are in an agreement with ***Deeb et al., (2017)*** who carried out a study entitled *"Accurate Carbohydrate Counting Is an important Determinant of Postprandial Glycemia in Children and Adolescents with Type 1 Diabetes on Insulin Pump Therapy"* and found that the mean age of the studied sample was 13 and most of them were females.

From the researcher point of view, less than half of them were at the age between 14<16 years this may be because parents are keen to bring their children to follow up the physical changes that happen especially during puberty and to follow up their glycemic control. Females show more compliance to attend the follow up visits to the clinic due to fear from the disease effect on future engagement and child-bearing. After the age of 16, adolescents are more independent and rebellious to committing to their clinic follow up visits.

As regards medical history of the studied adolescents with type 1 diabetes, the results of the present study revealed that more than one third had more than 6 years duration of the disease ($\bar{X}$ ±SD 6.073 ± 4.172 year), almost half of them presented with hyperglycemic symptoms at diagnosis, almost half of them had a previous hospitalization, less than two thirds had been previously hospitalized due to DKA and more than three quarter of them had previous family history of diabetes mellitus.

This finding is in an agreement with ***Enander et al., (2017)*** who conducted a study entitled *"Carbohydrate Counting with A bolus Calculator Improves Post-Prandial Blood Glucose Levels in Children and Adolescents with Type 1 Diabetes using Insulin Pumps"* and found that the duration of the diabetes was 8.0 ± 3.8 year. Moreover, the results are also similar to those of ***Gabriel et al. (2016)***, who conducted a study entitled *"Training Adolescents with Type 1 Diabetes to Carbohydrate Counting without Parents"* and found that the duration of diabetes was 4.0 ± 3.0 year.

From the researcher's point of view the increased rate of hospitalization and incidence of DKA episodes is attributed to lack of parents' supervision, non-adherence of adolescents with type 1 diabetes to insulin therapy. Moreover, poor diet management results in hypo- or hyperglycemic complications and recurrent hospitalization.

As regarding follow up with nutritionist, the results of the present study revealed that the majority of the adolescents with type 1 diabetes had not followed with nutritionist. These results was are in disagreement with ***Arslan (2019)*** who conducted a study entitled *"Assessment of Carbohydrate Count Method Knowledge Levels and Insulin Types of Individuals with Type 1 DM"* and found that more than half of the subjects follow up with a dietitian. Moreover, the results are also in disagreement with ***Gabriel et al., (2016)*** who found that nearly two thirds follow up with a nutritionist.

The present study findings revealed that despite the adolescents' previous attendance of educational sessions about nutritional planning, as mentioned by the attended subjects, these sessions were not held on a regular basis, and sometimes they were not able to commit to what was explained resulting in poor compliance and adherence to nutritional instructions.

As regards the adolescents with type 1 diabetes mellitus glycemic control, the results of the present study revealed that the majority had pre-prandial blood glucose level ≥130 mg/dL, more than two thirds had post-prandial blood glucose level > 180 mg/dL and less than half had HbA1C 8-<10 % with X± SD 9.7 ± 2.343 mg/dL. The results are comparable to those of ***Son et al., (2014)*** who conducted a study entitled "*Investigation on Carbohydrate Counting Method in Type 1 Diabetic Patients*" and found that X±SD of the pre-prandial test was 149.63 ± 17.65 mg/dL, X±SD of the post-prandial test was 174.59 ± 15.46 mg/dL and X±SD of the HbA1C was 8.14 ± 0.48 %.

Moreover, the present study results was in accordance with ***Dias et al., (2011)*** who found that X±SD of the pre-prandial test was 176.5±24.34 mg/dL, X±SD of the post-prandial test was 247.5±16.5 mg/dL and X±SD of the HbA1C was 10.0±1.458 %.

From the researcher's point of view high levels of pre-prandial blood glucose, post-prandial blood glucose, and HbA1C in the current study might be due to many adolescents missing insulin doses , non-adherence to nutritional therapy as they feel different from their peers, lack of parents' supervision and lack of awareness regarding value of carbohydrate content estimation.

Regarding to PCQ total score, the finding of the present study showed that the total PCQ score X±SD was 32.03±10.34, which is quite low. The results are in disagreement with ***Gurnani et al., (2018)*** who conducted a study entitled *"One Potato, Two Potato,. Assessing Carbohydrate Counting Accuracy in Adolescents with Type 1 Diabetes" and* found that X±SD of PCQ total score was 81±10 %. Moreover, the results also disagree with ***Finner et al., (2015)*** who conducted a study entitled *"Knowledge of carbohydrate counting and insulin dose calculations in pediatric patients with type 1 diabetes mellitus"* and found that X±SD of PCQ total score was 66.3 ± 16.2 %.

From the researcher point of view the difference is due to that adolescents with type 1 diabetes in the recent study still felt restricted when following up with a nutritionist, and they did not follow the instructions and searched for feeling free in diet choices without counting like for example increased intake of "fast food" with lack of adherence to carbohydrate content estimation. I could be also attributed to that many adolescents do not attend the clinic for periodic follow up and only parents attend for dispensing insulin.

As regards correlation between adolescents with type 1 diabetes glycemic control and their total PCQ score, the results of the present study revealed that there was a negative but non-significant correlation between glycemic control and total PCQ score. The results are consistent with ***Finner et al., (2015)*** who found that there was insignificant relation

between total PCQ score and glycemic control. The results of this study disagree with ***Mullen et al., (2019)*** who conducted a study entitled *"The Effect of Carbohydrate Recognition and Counting Ability on Glycemic Control in Pediatric Patients with Type 1 Diabetes"* and found that there was a negative and significant correlation between total PCQ score and HgbA1C.

From the researcher's point of view this disagreement could be due to either non-compliance of the adolescents with type 1 diabetes in this study or the need to do carb counting in more sessions with applied sessions done repeatedly over several months to enforce applying carb counting in their daily practice

## Conclusion

According to the results of this study, it can be concluded that adolescents with type 1 diabetes had a low level of recognition regarding carbohydrate content estimation and there was negative but non-significant correlation between adolescents' with type 1 diabetes glycemic control and total PCQ score.

## Recommendations

In the light of findings of the present study, the following recommendations are suggested:

1.Enhance the awareness of the adolescents with type 1 diabetes about carbohydrate content estimation.

2.Study factors affecting carbohydrate content estimation for adolescents with type 1 diabetes.

## References

**American Diabetes Association (2022):** Professional Practice Committee. 6. Glycemic targets: standards of medical care in diabetes—2022. *Diabetes Care*;45 (Supplement_1): S83-S96.

**American Diabetes Association "ADA" (2020):** Improving Care and Promoting Health in Populations: Standards of Medical Care in Diabetes. Diabetes Care; 43 (Supplement 1): S7-S13

**Arslan (2019):** Assessment of Carbohydrate Count Method Knowledge Levels and Insulin Types of Individuals with Type 1 DM. Clin Exp Health Sci 2019; 9; 345-349.

**Canadian Diabetic Association (2020):** Carbohydrate Counting for Diabetes Management. Diabetes Canada Clinical Practice Guidelines 2. Retrieved at: https://www. Canadian-diabeticasociation.com Accessed on 12 January2022)

**Center of Disease Prevention and Control (2021):** Tests for Type 1, Type 2 and Prediabetes. Retrieved at: **https://www.**CDC.gov. Accessed on: 21 December 2021.

**Deeb A., Al Hajeri A., Almahmoudi I. & Nagelkerke N. (2017):** Accurate Carbohydrate Counting Is an important Determinant of Postprandil Glycemia in Children and Adolescents with Type 1 Diabetes on Insulin Pump Therapy. J Diabetes SCi Technol. 11(4):753-758.

**Dias M., Pandini A., Nunes R., Sperandei S., Portella M., Cobas M. & Gomes M. (2011):** Effect of the carbohydrate counting method on glycemic control in patients with type 1 diabetes. Diabetology & Metabolic Syndrome, 2:54.

**Enander R., Gundevall C., Stromgren A. & Chaplin J. (2017):** Carbohydrate Counting with A bolus Calculator Improves Post-Prandial Blood Glucose Levels in Children and Adolescents with Type 1 Diabetes using Insulin Pumps. Pediatric diabetes: 13:545-551.

**Evert A., Dennison M., Gardner C. et al, 2019:** Nutrition therapy for adults with

diabetes or prediabetes: a consensus report. Diabetes Care; 42:731–54

**Finner N, Quinnb A, Donovan A, O'Leary A & O'Gorman A. (2015):** Knowledge of carbohydrate counting and insulin dose calculations in paediatric patients with type 1 diabetes mellitus. BBA Clinical 4: 99–101.

**Franz M.J., MacLeod J., Evert A., Brown C., Gradwell E., Handu D., Reppert A. & Robinson M. (2017):** Academy of Nutrition and Dietetics nutrition practice guideline for type 1 and type 2 diabetes in adults: systematic review of evidence for medical nutrition therapy effectiveness and recommendations for integration into the nutrition care process. Journal of the Academy of Nutrition and Dietetics;117(10):1659-79.

**Gabriel B., Albuquerque C., Consoli M., Menezes P. & Reis J. (2016):** Training Adolescents with Type 1 Diabetes to Carbohydrate Counting without Parents help. Rev. Nutr., Campinas, 29(1):77-84.

**Gurnani M. Pais V., Cordeiro K., Steele S., Chen S., & Hamiliton J. (2018):** One potato, two potato,… assessing carbohydrate counting accuracy in adolescents with type 1 diabetes. Pediatric Diabetes;19:1302–1308.

**Heryanda, M. F., Briawan, D. & Sudikno, S. (2020):** Changes in Diet Quality of Adults Patients with Type Two Diabetes : Cohort Study of NonCommunicable Diseases Risk Factors. Amerta Nutr. 4, 318.

**International Diabetes Federation "IDF" (2019):** Diabetes Atlas 9th Edition. Retrieved at: https://www. Diabetesatlas.org/en/. Accessed on 2 December 2021).

**Koontz, L. Cutler M. Palmert,. O'Riordan, E.A. Borawaski, J. McConnell, E. O'Kern (2010):** Development and validation of a questionnaire to assess carbohydrate and insulin-dosing knowledge in youth with type 1 diabetes, Diabetes Care 33 (3) 457–462.

**Liu F., et al. (2017):** Effect of inulin-type fructans on blood lipid profile and glucose level: a systematic review and meta-analysis of randomized controlled trials. European Journal of Clinical Nutrition;71: 9–20.

**Mullen M., Minutti C., Keim K., & Parish A (2019):** The Effect of Carbohydrate Recognition and Counting Ability on Glycemic Control in Pediatric Patients with Type 1 Diabetes. Journal of the academy of Nutrition and Diabetics:118(9):28-33

**National Institute of Diabetes and Digestive and Kidney Diseases. (2021):** (https:// www.niddk.nih. gov/ health-inform-ation/diabetes) Accessed 25/7/2021.

**Patra K. (2022):** HbA1c (Hemoglobin A1c) A1c Chart, Test, Levels, & Normal Range**.** Retrieved at: **https:// www. Breathe wellbeing .in/ blog/hba1c-a1c-chart-test-levels-normal-range/.** Accessed on: 11 April 2021.

**Reiterer F & Freckmann G. (2019):** Advanced carbohydrate counting: an engineering perspective. Annu Rev Control; 48:401–422.

**Rogers M.A., Kim C., Banerjee T. & Lee J.M. (2017):** Fluctuations in the incidence of type 1 diabetes in the United States from 2001 to 2015: a longitudinal study. BMC medicine;15(1):199.

**Smart C.E., Annan F., Bruno L.P., Higgins L.A. & Acerini C.L. (2014):** Nutritional management in children and adolescents with diabetes. Pediatric diabetes; 15(S20):135-53.

**Son O., Efe B., Son E., Akalin A., & Kebapçi N. (2014):** Investigation on Carbohydrate Counting Method in Type 1 Diabetic Patients. BioMed Research International. Article ID 176564.