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EFFECT OF CARBOHYDRATE CONTENT ESTIMATION ON ADOLESCENTS' GLYCEMIC CONTROL

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Abstract

Background: Carbohydrate content estimation is the nutritional therapy of choice in T1DM, which allows flexible food choices and adolescents may consume any food in a healthy eating plan. However, adjusting the insulin dose to carbohydrate intake could produce potential improvement in glycemic control **Aim:** The aim of this study was to evaluate the effect of carbohydrate content estimation on adolescents' glycemic control. **Research Design**: Quasi experimental (pretest - posttest) design was used to conduct this study **.setting:** The study was conducted in outpatient Children Diabetes Clinic/Children's Hospital/Ain Shams University. **Subjects:** A Convenient sample included 81 adolescents with type 1 diabetes aging from 12:18 years. **Data collection tools:** First tool, diabetic adolescent assessment sheet to gather data related to adolescents' characteristics, illness history and physiological assessment, second tool was, Ped Carb Quiz (PCQ) to assess the studied adolescents' carbohydrate recognition and insulin dosing**. Results:** The results of this study revealed that there was a highly significant difference between total carbohydrate recognition domain and insulin dosing domain pre and post carbohydrate content estimation and also there was significant difference pre-prandial and post-prandial pre and post carbohydrate content estimation. **Conclusion:** it can be concluded that the implementation of carbohydrate content estimation affected positively the adolescents' glycemic control. **Recommendation:** Enhance the awareness of the adolescents with type 1 diabetes about carbohydrate content estimation.

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

INTRODUCTION

Diabetes Mellitus, also known as "DM," is a chronic condition that develops when the body is unable to absorb glucose into cells and use it. This results in a persistent rise in blood glucose levels (hyperglycemia), which increases the risk of morbidity and mortality. Diabetes is brought on by a shortage of insulin produced by the pancreas, a problem with how insulin is absorbed by the body, or both ***(National Institute of Diabetes and Digestive and Kidney Diseases, 2021).***

Type 1 diabetes mellitus is an autoimmune condition brought on by the immune system's activation of the pancreatic beta-cells, which produce insulin. T1DM is brought on by a combination of genetic and environmental variables that work together to produce

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disease vulnerability. T1D's pathophysiology, like that of other autoimmune diseases, is brought on by an immunological imbalance between pro-inflammatory T-helper 1 (Th1) cells and anti-inflammatory T-helper 2 (Th2) cells ***(Williams et al., 2019).***

There are numerous risk factors for acquiring diabetes, including genetic factors, epigenetic, environmental, and immunological variables, even if the origin of T1DM is unknown. The ADA estimates that between 10 and 15% of patients have a first- or second-degree relative who has diabetes. The Major Histocompatibility Complex (MHC) area, also known as the Human Leucocyte Antigen (HLA) region and found on chromosome 6, contains the majority of the genes responsible with T1DM susceptibility. Polymorphic alleles of the HLA complex account for 40–50% of the hereditary risk of developing T1DM ***(Ferri, 2018) .***

Financial constraints, cultural barriers, language barriers, literacy, educational barriers, family obligations, a lack of convenient access to healthcare health care resources, misconceptions and fears about the risks and benefits of diabetic treatments, and a lack of family or social support are just a few of the reasons why adolescents do not adhere to a diabetic treatment regimen or adhere to it inconsistently and incompletely ***(American Diabetic Association "ADA", 2020).***

The prevention of problems in T1DM relies heavily on nutrition. Blood glucose control and quality of life are immediately impacted by nutrition, carbohydrate counting, and education. On the risk of complications in T1DM, rigorous diabetic therapy, including intense glycemic control and nutritional management, is advantageous. To avoid T1DM problems, adolescents should be urged to continue taking insulin and receiving nutritional therapy ***(Matuleviciene-Anängen et al., 2017).***

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).***

It is critical to highlight the potential benefits of implementing carbohydrate content estimation for diabetic adolescents, including how it can give them knowledge, experience, and flexibility in meal planning about carbohydrate content estimation and how to overcome the typical challenges they face when implementing this type of nutritional therapy. The members of the healthcare team can use these data to develop a future plan of care for this patient group. Furthermore, teenagers' accurate estimation of carbohydrate intake can enhance glycemic control and reduce the risk of diabetic complications that are linked to morbidity, repeated ICU hospitalization, and mortality.

Aim of the study: To evaluate the effect of carbohydrate content estimation on adolescents' glycemic control

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Research hypothesis: The implementation of carbohydrate content estimation will affect positively on adolescents' glycemic control.

Research design: Quasi experimental (pretest - posttest) design was used to conduct this study.

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

Sample: A Convenient sample include all the adolescents with type 1 diabetes using EPI Info 7 program for sample size calculation with margin of error = 10 % and at 95 % confident level, sample size of 81 adolescents with type 1 diabetes was needed ***(Community, Environmental and Occupational Medicine Department, Faculty of Medicine, Ain Shams University,2020).***

Tools for data collection: 1 **- Adolescents assessment sheet (by interview):** It was designed by the researcher in an Arabic language to assess the data as 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 of the diabetes:** 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).

Scoring system: 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).***

2- **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 the 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 domains include three sub-domains; first, is the use of correct insulin dose based on blood glucose

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level, second is the 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 and 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. Maximum score for carbohydrate recognition domains is 58 distributed over 1 degree 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 degree for each sub-item; first, correct insulin dose 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. The total number of PCQ items is 78; the maximum overall obtainable score was 78/78. Higher scores indicate greater degree of recognition about carbohydrates and insulin-dosing ability.

Tool validity and reliability: 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.

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 Chronbach 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 correct insulin dose 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.

Protection of ethical and human rights: 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.

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Procedure: 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 in Tuesday and Wednesday 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. The study subjects were oriented about the aim and expected outcomes of the study and they 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. 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) was assessed by reviewing the self-documented readings done by the adolescents of blood glucose levels of 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 $HbA1_C$ 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. The Ped Carb Quiz was used to assess seven domains; four carbohydrate recognition domains includes: first recognition of carbohydrates, second, carbohydrate counting in individual food items, third, carbohydrate counting in whole meals, while fourth is nutrition label reading. The three insulin dosing domain includes 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. The carbohydrate content estimation was discussed with the adolescents and their families individually about foods containing carbohydrates, amount of carbohydrate in each type of food, how to read nutritional label facts and how to count carbohydrate in whole meal to acquaint each study subject with knowledge and practices regarding carbohydrate content estimation using different teaching methods such as tables, pamphlets and pictures.

After the insulin to carb ratio was determined by the treating physician, the adolescents were educated how to use correct insulin dose based on blood glucose level, how to use of insulin-to-carbohydrate ratio in insulin dosing and how to calculate whole meal insulin dose .

The session was held for 60-90 min for each adolescent and the items were repeated for many times to ensure that they understand the instructions. After accomplishment the educational session, a brief conclusion was done was done using the Ped carb quiz. Follow up with the adolescents included in this study either during their next visits to the clinic, via telephone calls or using whatsapp application was done to assess their compliance to carbohydrate content estimation.

During the three months following the educational session with the adolescent, they were assessed for their physiological data (glycemic); pre-prandial and post-prandial blood

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glucose. Physiological data was assessed by reviewing the self-documented readings done by the adolescents of blood glucose levels either were hand written in a blood glucose monitoring log or recorded on their blood glucose monitoring device .

After three months the adolescents were asked to perform HbA1c test. The last case to be followed was scheduled at the 10th of October, 2022, and there were many cases did not perform the test, so extend the time till 10th of November was allowed for the adolescents to perform the test. In 10th of November all the adolescents were assessed for their compliance to carbohydrate content estimation and the physiologic data; pre-prandial and post-prandial blood glucose, but there were 25 adolescent did not perform HB HbA1c test. Those adolescent were asked for the reason and all of them replied that, they were previously do these tests at the hospital and now this service is not available and it is expensive to do on their own for some families.

Results:

Table 1: Characteristics of 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
$\bar{X}$ ±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 (1): This table showed that nearly half (46.9%) of the included adolescents with type 1 diabetes were at the age between 14<16 years ($\bar{X}$±SD 14 ± 1.849 years), 67.7% were females and almost one third (34.6%) of them were studying at preparatory school.

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Table 2: Diabetes related data of included adolescents with type 1 diabetes (n=81).

Medical history	**No.**	**%**
Past family history of DM		
Yes	**64**	**79.0**
No	17	21.0
Duration of Diabetes (years)		
< 3	23	28
3: ≤ 6	25	31
> 6	**33**	**41**
$\bar{X}$ ±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 acute complications resulting in hospitalization		
Yes (n=40)	40	49.4
DKA	**26**	**65.0**
Hypoglycemia	7	17.5
Glycemic Coma	7	17.5
No	41	50.6

Table (2): This table illustrated that more than one third (41 %) of the adolescents with type 1 diabetes had more than 6 years duration of the diabetes ($\bar{X}$ ±SD 6.073 ± 4.172 year), almost half of them (50.6 %) presented with hyperglycemic symptoms at diagnosis, almost half of them (49.4 %) had previous hospitalization, less than two thirds (65 %) among them had previously been hospitalized due to DKA and more than three quarters (79 %) of them had previous family history of diabetes mellitus

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Table 3: Distribution of the studied adolescents with type 1 diabetes according to their glycemic assessment pre and post carbohydrate content estimation (n=81).

Adolescents glycemic assessment	Pre		Post		t-test	*P value*
	No.	%	No.	%		
Pre-prandial blood glucose (mg/dL)						
< 80	1	1.2	3	3.8		
80 - < 130	12	14.8	38	46.9		
≥130	**68**	**84**	**40**	**49.3**		
X̄ ±SD	141.98±21.30		124.81±18.72		6.163	<0.001**
Post-prandial blood glucose (mg/dL)						
≤ 180	25	30.8	35	43.3		
> 180	**56**	**69.2**	**46**	**56.7**		
X̄ ±SD	210.62±31.59		190.86±28.63		4.134	<0.001**
Glycated hemoglobin (%)						
Not done	3	3.7	25	30.8		
< 6	1	1.3	1	1.3		
6 - < 8	14	17.4	10	12.3		
8 - <10	**39**	**48.3**	**23**	**28.4**		
≥ 10	24	29.3	22	27.2		
X̄ ±SD	9.7 ± 2.343		10.03 ± 2.516		*t:*0.338	0.737

P-value >0.05 is insignificant; **p-value <0.001 highly significant

Table (3): This table showed that there was highly significant difference between pre-prandial and post-prandial blood glucose pre and post carbohydrate content estimation with p-value <0.001 while there was a non-significant difference between HbA1c pre and post carbohydrate content estimation with p-value >0.05.

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

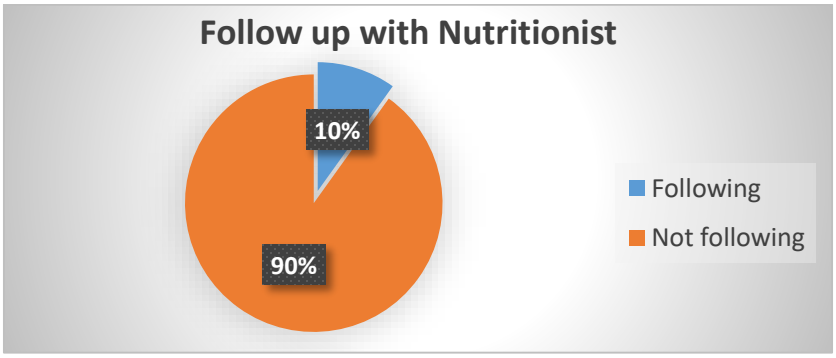

Figure (1):- This figure revealed that the majority (90%) of the adolescents with type 1 diabetes never follow up with a nutritionist.

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Table 4: Mean score of carbohydrate recognition domain among the studied adolescents with type 1 diabetes pre and post carbohydrate content estimation (n=81).

Carbohydrate Recognition Domain	Pre	Post	t-test	*P value*
	X̄ ±SD	**X̄ ±SD**		
Carbohydrate recognition	57.2 ± 11.91	80.28 ± 9.7	9.802	<0.001**
Carbohydrate counting in an individual item	22.84 ± 13.55	56.23 ± 13.4	11.649	<0.001**
Nutritional label reading	7.56 ± 11.97	34.26 ± 16.41	12.596	<0.001**
Carbohydrate counting in a whole meal	22.53 ± 11.43	56.46 ± 14.18	7.221	<0.001**
Total score	42.02 ± 10.33	69.11 ± 9.99	6.166	<0.001**

Table (4): This table illustrated that there was a highly significant difference in carbohydrate recognition domain pre and post carbohydrate content estimation with p-value <0.001.

Table 5: Mean score of insulin dosing domain among the studied adolescents with type 1 diabetes pre and post carbohydrate content estimation (n=81).

Insulin Dosing Domain	Pre	Post	t-test	*P value*
	X̄ ±SD	**X̄ ±SD**		
Use of correct insulin dose	21.81 ± 10.75	52.55 ± 13.99	9.366	<0.001**
Use of insulin to carbohydrate ratio	24.49 ± 14.21	65.64 ± 16.43	10.934	<0.001**
Calculation of whole meal insulin dose	20.37 ± 10.16	56.17 ± 13.19	12.763	<0.001**
Total score	22.04 ± 9.35	60.93 ± 12.77	7.855	<0.001**

According to table (5), this table revealed that there was a highly significant difference in insulin dosing domain pre and post carbohydrate content estimation with p-value <0.001.

Table 6: Mean score of total PCQ score among the studied adolescents with type 1 diabetes pre and post carbohydrate content estimation (n=81).

Total PCQ Score	Pre	Post	t-test	*P value*
	X̄ ±SD	**X̄ ±SD**		
Carbohydrate recognition domain	42.02 ± 10.33	69.11 ± 9.99	6.166	<0.001**
Insulin dosing domain	22.04 ± 9.35	60.93 ± 12.77	7.855	<0.001**
Total score	32.03 ± 9.34	65.02 ± 11.38	11.216	<0.001**

Table (6): This table showed there was a highly significant difference between total carbohydrate recognition domain and insulin dosing domain pre and post carbohydrate content estimation with P-value <0.001.

DISCUSSION

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

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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 evaluate the effect of carbohydrate content estimation on adolescents' glycemic control.

Regarding the characteristics of the studied adolescents with type 1 diabetes, the finding of the present study showed that less than 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 <16 years this may be attributed to parents are keen to bring their children to follow the physical changes that happen especially during puberty. The adolescents ≥16 years show less attendance to the clinic as they become more independent and less caring to come for follow up. Females show more compliance to attend the follow up visits to the clinic due to fear from the diabetes.

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 diabetes ($\bar{X}$ ±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 quarters 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 also was similar with ***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.

The results of this study disagree with ***Duca et al., 2017*** who carried out a study entitled *"Diabetic Ketoacidosis at Diagnosis of Type 1 Diabetes Predicts Poor Long-term Glycemic Control"* and found that nearly one fifth had presented with DKA at diagnosis of T1DM. From the researcher's point of view the increased rate of DKA at presentation of diagnosis and increased rate of previous hospitalization and incidence of DKA episodes is attributed to lack of parents' supervision, non-adherence of adolescents with type 1 diabetes to insulin therapy and poor diet management resulting 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

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results was disagree 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 had follow up with a dietitian. Moreover, the results also was disagree with ***Gabriel et al., (2016)*** who found that less than two thirds had follow up with a nutritionist.

From the researcher's point of view the difference is due to despite their previous attendance of educational sessions about nutritional planning, as mentioned by the attended subjects, these sessions is not held in a regular basis to follow their compliance and adherence to instructions.

As regards the adolescents with type 1 diabetes mellitus glycemic control, the results of the present study revealed that there was a statistically significant difference between pre-prandial, post-prandial and random blood sugar pre and post carbohydrate content estimation. The results agreed with ***Gokosmanoglu and Onmez (2018)*** who conducted a study entitled *"Influence of Flexible Insulin Dosing with Carbohydrate Counting Method on Metabolic and Clinical Parameters in Type 1 Diabetes Patients" and found that there was a statistically significant difference between fasting, post-prandial and random blood sugar pre and post using flexible insulin dosing with carbohydrate counting.*

Moreover, the results also revealed that there was no significant difference in HbA1c pre and post carbohydrate content estimation. The results disagreed with **Gokosmanoglu and Onmez (2018)** who found that there was a statistically significant difference between $HbA1_c$ pre and post using flexible insulin dosing with carbohydrate counting.

From the researcher point of view this may be due to 25 adolescents in this study had not followed their HbA1c which affect the results. It may be also attributed to that HbA1c results needs compliance for long time regarding medical and nutritional therapy to achieve changes in HbA1c results.

As regards total PCQ score, the results of this study showed that there was a highly significant difference pre and post carbohydrate content estimation. The results were in an agreement with **Vanita (2020)** who carried out a study entitled "Counting Carbs to Be in Charge": A Comparison of an Internet Based Education Module with In-Class Education in Adolescents With Type 1 Diabetes" and found that there was a significant increase in adolescents PCQ score post carbohydrate counting training program.

From the researcher point of view, in-class training sessions help the researcher to ensure that the adolescents with type 1 diabetes had understood the program and clarify any unclear points and in the end it results in an improvement in their knowledge.

Conclusion: According to the results of this study, it can be concluded that the implementation of carbohydrate content estimation affected positively adolescents' glycemic control.

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Recommendation:

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

1. Enhance the awareness of the adolescents with type 1 diabetes about carbohydrate content estimation.
2. Applying protocols for nutritional guidelines should be integrated with nutritionist regarding carbohydrate content estimation and its effect on glycemic control.
3. Overcome barriers that hinder use carbohydrate content estimation
4. Further studies with large samples to investigate the effect of carbohydrate content estimation on glycemic control of adolescents with T1DM.

Conflict of Interest: The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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