Nepalese Medical Journal, (2021) Vol. 4, 419 - 423

Original Article

Effect of Dietary Intervention Using Low-Carbohydrate Diet to Manage Newly Diagnosed Type 2 Diabetes Mellitus in Tribhuvan University Teaching Hospital

Aarem Karkee[1,6], Samir Singh[2], Pradeep Krishna Shrestha[3], Nani Shova Shakya[4], Sadiksha Shrestha[5], Samiksha Niroula[1]

[1]*Department of Nutrition and Dietetics, College of Applied Food and Dairy Technology, Kathmandu, Nepal*

[2]*Department of Biochemistry, KIST Medical College, Lalitpur, Nepal*

[3]*Department of Internal Medicine, Tribhuvan University Teaching Hospital, Kathmandu, Nepal*

[4]*Department of Dietetics, Tribhuvan University Teaching Hospital, Kathmandu, Nepal*

[5]*Department of Biochermistry, Tribhuvan University Teaching Hospital, Kathmandu, Nepal*

[6]*Department of Nutrition and Dietetics, Patan Academy of Health Science, Lalitpur, Nepal*

ABSTRACT

Introduction: Low-carbohydrate diet is effective in improving blood glucose parameters, glycated hemoglobin A1c, weight, and waist circumference. The effectiveness of this diet is well accepted in America and the United Kingdom but in Nepal due to many preexisted misbeliefs regarding carbohydrates, we still have a carbohydrate-based diet for type 2 diabetes mellitus.

Material and Methods: Fifty-four newly diagnosed type 2 diabetes mellitus without any treatment were selected for solely low-carbohydrate diet intervention (<130g carbohydrate) in the endocrinology unit of Tribhuvan University Teaching Hospital, Kathmandu from March to August 2019. Antidiabetic medications were not used. Individualized diet plans and repeated counseling were given and followed for 3 months. Blood glucose (fasting and postprandial), glycated hemoglobin A1c, weight, and waist circumference were compared at entry and 3 months. Statistical analysis was done using SPSS version 21.

Results: The mean ± SD age was 44.77 ± 10.32. The mean body weight decreased by 4.52 ± 1.79 kg (p<0.001), mean waist circumference decreased by 7.85±0.72 cm (p<0.001), mean fasting blood glucose decreased from 10.44±3.52 mmol/L to 6.18±1.02 mmol/L (p<0.001), mean postprandial blood glucose decreased from 16.76±8.26 mmol/L to 8.26±1.66 mmol/L (p<0.001) and mean glycated hemoglobin A1c decreased by 2.38 ± 1.49 % (p<0.001) after 3 months of low-carbohydrate diet intervention.

Conclusions: The use of a low-carbohydrate diet may effectively produce glycemic control and decrease glycated hemoglobin A1c without medication in newly diagnosed type 2 diabetes mellitus. Additionally, this diet may also help to lower weight and waist circumference in newly diagnosed type 2 diabetes mellitus.

Keywords: Low-carbohydrate diet, HbA1c; Type 2 diabetes mellitus

Correspondence:
Aarem Karkee
Dietitian, Department of Nutrition and Dietetics
Patan Academy of Health Science, Lagankhel, Lalitpur, Nepal
ORCID ID: 0000-0002-9077-2834
Email: aaremcarkey@gmail.com

Submitted: 3rd February 2021
Accepted: 28th June 2021

Source of Support: None

Conflict of Interest: No
Citation: Karkee A, Singh S, Shrestha PK, Shakya NS, Shrestha S, Niroula S. Effect of Dietary Intervention Using Low-Carbohydrate Diet to Manage Newly Diagnosed Type 2 Diabetes Mellitus in Tribhuvan University Teaching Hospital. NMJ 2021;4(1):419-23. DOI 10.3126/nmj.v4i1.34710

INTRODUCTION

For the first time in 2019, American Diabetes Association (ADA) stated in "Standards of Medical Care in Diabetes-2019" that it is beneficial to follow a low-carbohydrate diet (LCD) for the management of Type 2 Diabetes Mellitus (T2DM). They made this statement by citing different researches done on LCD and its effects on T2DM. They extend the benefits of LCD to also have the potential to reduce antihyperglycemic medications.[1] Diabetes UK also agrees that LCD is effective in reducing weight and improving glycemic control in T2DM.[2]

The prevalence of T2DM in Nepal is not exactly known as data is not available at the government level but a study published showed the prevalence of diabetes in Nepal to be 8.5%.[3] Moreover, diabetes is among the top 10 causes of death in Nepal.[4]

Several studies showed a link between carbohydrate intake (measured as glycemic index and load) with risk of T2DM such as Nurses Health Study[5], Health Professional Follow-Up Study[6], and Framingham Offspring Study.[7] High carbohydrate diets which have 50–60% calories from carbohydrates have been used as standard protocol for patients with T2DM.[8] Evidence suggests that with an increase in the amount of carbohydrates in the diet, there is a decrease in glycemic control whereas a low amount of carbohydrates helps in glycemic control.[9]

Carbohydrate intake influences blood glucose which is basic biochemistry as most of the carbohydrates are converted into glucose molecules before they are absorbed in the body.[10] So, it was obvious to prescribe carbohydrate-restricted LCD to diabetic patients before the discovery of insulin.[11]

LCD not only improves glycemic control but also complications associated with high blood glucose such as lipid profile, insulin resistance, weight, BMI, and inflammation.[12] Standard definition of LCD is not made yet. The following table shows the most commonly used classification of diet according to the amount of carbohydrates.[13]

Table 1: Classification of diet according to the amount of carbohydrates

Description	Amount of carbohydrate	
	g/day	% total energy intake
Very low-carbohydrate ketogenic diet	20–50	≤10
Low-carbohydrate	<130	<26
Moderate carbohydrate	130–230	26–45
High carbohydrate	>230	>45

The purpose of this study was to evaluate the effects of LCD in newly diagnosed T2DM patients over 3 months. We wanted to know the effect of this diet on blood glucose (fasting and postprandial), HbA1c, weight, BMI, and waist circumference of newly diagnosed T2DM patients without antidiabetic medications.

MATERIALS AND METHODS

The pretest-posttest experimental study in newly diagnosed type 2 diabetes mellitus patients was conducted in the endocrinology department of Tribhuvan University Teaching Hospital, Kathmandu, Nepal. Patients were enrolled and dietary intervention was conducted. The research was done from March to August 2019.

Inclusion criteria were; newly diagnosed T2DM patients based on WHO criteria[1] not on any medications. Exclusion criteria were; pregnant and lactating women, renal failure, liver failure, cancer, unstable heart disease, on medication for T2DM, on medication for weight reduction, and a patient who could not be followed.

The sample size was calculated for the matched paired t-test. After adjusting the effect size to 0.5, error to 0.05, and power to 0.95, the sample size was 54. The sample size was calculated from G*power software.

Written informed consent was taken from participants before intervention. Confidentiality and privacy of the participants were maintained. Ethical approval was obtained from the College of Applied Food and Dairy Technology, Kathmandu, and approval was also obtained from the Tribhuvan University Teaching Hospital.

At the first visit, participants were instructed to follow LCD. Participants had different food habits (Vegetarian/Non-vegetarian but not any vegan), the timing of the meal, available foods as well as likes and dislikes. They were put on an LCD considering these factors whereas the amount of carbohydrate (Low/moderate/high) they had been eating before the study was not considered. Participants were taught specific types and amounts of foods that they could eat as well as foods to avoid. An individualized sample diet was given to participants according to available foods and food choices. Also, they were counseled about the methods to exchange foods so that they could modify their diet and replace one food with another food. Participants were allowed to consume liberal amounts of meat, poultry, fish, eggs, ghee, and avocado, etc. The ultimate aim was to control the overall consumption of carbohydrates, not protein and healthy fats. Participants were counseled to consume carbohydrate-rich foods very cautiously to not exceed 130 g of carbohydrate per day. Participants were provided handouts that contained a sample diet plan and a list of foods. In addition, diabetes medications were not prescribed and only diet therapy was used.

Participants were followed once a week for the first 4 weeks and blood sugar was regularly monitored. After that contacts were made through cell phones every 15 days for a total of 3 months and anthropometric and biochemical measurements were done. Patients were constantly counseled whenever they call for a consultation.

The primary outcome of this study was HbA1c. HbA1c was selected as a primary outcome because it gives the overall picture of average blood sugar over months. Usually, it is done every 3 months this is the reason for setting study time 3 months. Secondary outcomes included change in fasting blood glucose (FBG), post-prandial blood glucose (PPBG), weight, body mass index (BMI), and waist circumference.

Weight was measured in standard Seca-scale, waist circumference was measured by a standard measuring tape, and height was measured with a stadiometer. Laboratory standard operating procedures were maintained for all laboratory analyses. Internal quality control sera, both normal and pathological, were also run for each lot, for the validation of the results. Routine investigations were carried out in a fully automated biochemistry analyzer, BT 1500, Italy.

FBG and PPBG were measured by glucose oxidase method, as described by Trinder, using commercial kit Biolabo Reagents, France. (Normal reference range: FBG=3.5-6. 1mmol/L .and PPBG- <8.3 mmol/L))

HbA1c was measured by Hb-Vario Analyzer which uses pressure cation exchange high-performance liquid chromatography (HPLC) in conjunction with gradient elution to separate human hemoglobin subtypes and variants from hemolyzed whole blood. (Normal Reference Range: 4.5-6.4%).

Data were described as mean±SD or number and percentage. Paired sample t-tests and Wilcoxon Signed-Ranked tests were performed in measured parameters. The significance (p-value) was set at 0.001. Statistical analysis was done using SPSS version 21.

RESULTS

The mean (Mean ± SD) age of the participant was 44.77 ± 10.32. Among 54 participants males were 32 and females were 22.

In regards to anthropometric measurements, the mean body weight decreased by 4.52 ± 1.79 kg from 71.02 ± 8.52 kg (53 kg - 89 kg) at baseline to 66.5 ± 7.67 kg (50 kg - 83 kg) after 3 months. BMI decreased by 1.76±0.72 kg/m^2 from 27.75±3.19 kg/m^2 at baseline to 25.9±4.2 kg/m^2 after 3 months. Waist circumference decreased by 7.85±0.72 cm from 95.92±9.10 cm at baseline to 88.06±6.7 cm after 3 months. Paired t-test was used for the statistically significant difference. Changes in body weight, waist circumference, and BMI decreased significantly at 3 months of dietary intervention (*p*<0.001). (fig. 1)

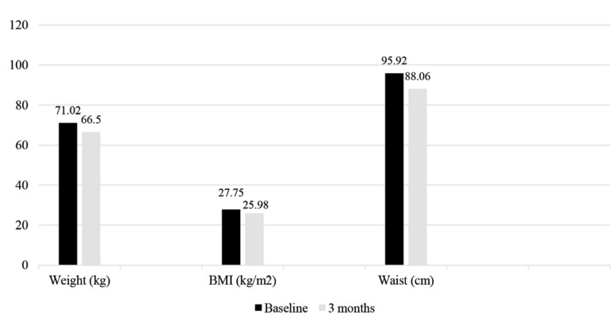

Figure 1: Mean of anthropometric measurements at the baseline and 3 months

The mean fasting blood FBS at baseline was 10.44±3.52 mmol/L and after 3 months of dietary intervention, it decreased to 6.18±1.02 mmol/L. (Table 2) Wilcoxon Signed-Rank test was done and was statically significant (*p*<0.001). (Table 2) The mean HbA1c decreased by 2.38± 1.49 % which was statistically significant (*p*<0.001). (Table 3)

Table 2: Serum test results (fasting and post prandial blood glucose)

Characteristics	Baseline Mean ± SD	3 months Mean ± SD	p-value
FBG	10.44 ± 3.52	6.18 ± 1.02	<0.001
PPBG	16.76 ± 6.12	8.26 ± 1.66	<0.001

**Wilcoxon signed-ranks test.*

Table 3: Serum test results HbA1c

Characteristics	Baseline Mean ± SD	3 months Mean ± SD	Mean Difference Mean ± SD	t-value	p-value
HbA1c (%)	9.19 ± 1.95	6.81 ± 1.01	2.38 ± 1.49	11.696	<0.001

* By paired t-test

DISCUSSION

In our study, 3 months long LCD intervention showed significant improvements in blood glucose indices, as measured by FBG, PPBG, and HbA1c, as well as in anthropometric indices, as measured by weight, waist circumference, and BMI in patients with T2DM.

Significant (P<0.001) reduction was found in mean FBG. Several studies are showing the benefits of LCDs in lowering blood glucose, HbA1c, and improvement in other complications associated with T2DM. William *et al.*, in 2005 found that with a low carbohydrate diet there was improved glycemic control with T2DM such that diabetes medications were discontinued or reduced in most participants, Also, Westman *et al.*, compared a low carbohydrate diet with a low glycemic index diet on controlling T2DM, and found that there are greater improvements in glycemic control, and more frequent medication reduction/ elimination with low carbohydrate diet than low glycemic index diet .[14, 15] Intake of carbohydrate increases blood glucose as carbohydrates ultimately get converted to glucose molecule and absorbed in bloodstream increasing the blood glucose concentration.[16] Similarly, a significant (*p*<0.001) reduction was found in mean PPBG. A decrease in PPBG can be understood as a smaller amount of carbohydrates means a lower spike in blood glucose because there is a small portion of carbohydrate converted to glucose.[17]

LCDs were shown to be effective in a reduction in weight, waist circumference, and BMI in studies.[8,14,18,19] This is because insulin drives fat gain as it is an anabolic hormone.[20] This mechanism is well illustrated in the carbohydrate-insulin model of obesity.[21] Weight loss is usually greater following the LCD as compared to other diets as seen in the study by Elhyany *et al.* where the mean weight loss for all patients was 8.3 kg; 7.7 kg for ADA diet (Diet recommended by American Diabetic Association), 7.4 kg for TM (Traditional Mediterranean) and 10.1 kg for LCM (Low carbohydrate Mediterranean) diets.[22]

A study done by Gannon and Nuttall in 2004 in eight T2DM patients with LCD where they were followed for only 5 weeks, found a dramatic improvement in FBS as compared to a high carbohydrate diet while none of the participants were being treated with oral hypoglycemic agents or insulin at the time of enrollment in the study. Less than 20% calorie was provided from carbohydrates. The mean FBS concentration before starting the control diet was 10 ± 0.6 mmol/L. After 5 weeks on the control diet, the FBS concentration was decreased to 159 ± 11 mg/dl (8.8 ± 0.6 mmol/L). The average body weight was 98 ± 4.5 kg at the beginning, after 5 weeks on the diet, the average weight was 96 ± 4.1 kg. From the observation of 24 hours integrated glucose concentration, there was a significant decrease in PPBG.[17]

Significant (p<0.001) reduction was found in mean HbA1c which decreased by 2.38± 1.49 % from 9.19 ±1.95 % to 6.81±1.01 % after 3 months. A similar result was found by Boden *et al.,* in 14 days study, strict LCD was applied to 10 obese patients with T2DM. The mean HbA1c decreased from 7.3% to 6.8%.[18] Similar result was found by Yamada *et al.,* in research done with non-calorie restricted <130g carbohydrate diet which showed that HbA1c has significantly decreased p<0.05 (baseline 7.6±0.4%, six months 7.0±0.7%, p=0.03).[19]

The benefits of low carbohydrates in T2DM were also shown by 6 months-long research done by Nielsen *et al.* in 2005. In this study, he set two groups, one with a low carbohydrate diet (20 % carbohydrates, 30 % protein, and 50 % fat), and another control group with a high carbohydrate diet (60 % carbohydrates, 15 % protein, and 25 % fat). After 6 months of intervention, there was a significant improvement in the low carbohydrate group as compared to a high carbohydrate control group. The mean changes in the low carbohydrate group and the control group respectively were (±SD): FBG: -3.4 ± 2.9 mmol/L and -0.6 ± 2.9 mmol/L; HBA1c: -1.4± 1.1% and -0.6 ± 1.4%; Body Weight: -11.4 ± 4 kg and -1.8 ± 3.8 kg; BMI: -4.1 ± 1.3 kg/m^2 and -0.7 ± 1.3 kg/m^2.[9]

Waist circumference decreased by 7.85±0.72 cm from 95.92±9.10 cm at baseline to 88.06±6.7 cm after 3 months. The greater health effect is seen when there is a reduction in waist circumference as it represents visceral fat.[23] Yancy *et al.* found waist circumference of T2DM reduced after following carbohydrate diet which decreased from 130.0 ± 10.5 cm to 123.3 ± 11.3 cm in 16 weeks with low carbohydrate diet.[14]

Recently done systematic review by Huntriss *et al.* in 2018, 18 studies showed beneficial effects of LCDs in the management of T2DM and comorbidities associated with it. They also found that this diet reduces the requirements of medication. This research also suggested that LCD with <130g carbohydrate is more achievable and sustainable as compared to strict LCD where carbohydrate is set to be <50g.[24]

The limitations in our research were lack of control group, short duration of the study, and small sample size due to limitation of time, financial, human, and other resources.

CONCLUSIONS

LCD for just 12 weeks was able to produce a clinically relevant reduction in glycemic and anthropometric parameters in newly diagnosed Nepalese T2DM patients. These results support the use of therapeutic LCD for the management of newly diagnosed T2DM patients in Nepal. Future studies of larger samples, longer duration, and with a control group are needed to better address questions about the effect of the LCD in NepaleseT2DM, compliance, and sustainability of the results.

REFERENCES

1. American Diabetes Association (ADA). Classification and Diagnosis of Diabetes: Standards of Medical Care in Diabetes-2019. Diabetes Care. 2019;42(Suppl 1):S46-S60. Crossref
2. Dyson PA, Kelly T, Deakin T, Duncan A, Frost G, Harrison Z, et al. Diabetes UK evidence-based nutrition guidelines for the prevention and management of diabetes. Diabet Med. 2011;28(11):1282-8. Crossref
3. Dhimal M, Karki KB, Sharma SK, Aryal KK, Shrestha N, Poudyal A, et al. Prevalence of Selected Chronic Non-Communicable Diseases in Nepal. J Nepal Health Res Counc. 2019;17(3):394-401. Crossref
4. Nepal Health Research Council (NHRC), Ministry of Health and Population (MoHP), Monitoring Evaluation and Operational Research (MEOR). Nepal Burden of Disease 2017: A Country Report based on the Global Burden of Disease 2017 Study. Kathmandu, Nepal: 2017. 2019. Website
5. Hu FB, Satija A, Rimm EB, Spiegelman D, Sampson L, Rosner B, et al. Diet Assessment Methods in the Nurses' Health Studies and Contribution to Evidence-Based Nutritional Policies and Guidelines. Am J Public Health. 2016;106(9):1567-72. Crossref
6. ArdissonKorat AV, Willett WC, Hu FB. Diet, lifestyle, and genetic risk factors for type 2 diabetes: a review from the Nurses' Health Study, Nurses' Health Study 2, and Health Professionals' Follow-up Study. Current nutrition reports. 2014;3(4):345-54. Crossref
7. McKeown NM, Meigs JB, Liu S, Saltzman E, Wilson PW, Jacques PF. Carbohydrate nutrition, insulin resistance, and the prevalence of the metabolic syndrome in the Framingham Offspring Cohort. Diabetes care. 2004;27(2):538-46. Crossref
8. Arora SK, McFarlane SI. The case for low carbohydrate diets in diabetes management. Nutr Metab. 2005;2:16. Crossref
9. Nielsen JV, Jönsson E, Nilsson AK. Lasting improvement of hyperglycaemia and bodyweight: low-carbohydrate diet in type 2 diabetes--a brief report. Ups J Med Sci. 2005;110(1):69-73. Crossref
10. Silva ME, PupoAA, Ursich MJ. Effects of a high-carbohydrate diet on blood glucose, insulin and triglyceride levels in normal and obese subjects and in obese subjects with impaired glucose tolerance. Braz J Med Biol Res. 1987;20(3-4):339-50. Website
11. Westman EC, Yancy WS, Humphreys M. Dietary Treatment of Diabetes Mellitus in the Pre-Insulin Era (1914-1922). Perspectives in Biology and Medicine. 2006;49(1):77-83. Crossref
12. Kelly T, Unwin D, Finucane F. Low-Carbohydrate Diets in the Management of Obesity and Type 2 Diabetes: A Review from Clinicians Using the Approach in Practice. Int J Environ Res Public Health. 2020;17(7):2557. Crossref
13. Dyson P. Low Carbohydrate Diets and Type 2 Diabetes: What is the Latest Evidence? Diabetes Ther. 2015;6(4):411-24. Crossref
14. Yancy WS, Jr., Foy M, Chalecki AM, Vernon MC, Westman EC. A low-carbohydrate, ketogenic diet to treat type 2 diabetes. Nutr Metab. 2005;2:34. Crossref
15. Westman EC, Yancy WS, Jr., Mavropoulos JC, Marquart M, McDuffie JR. The effect of a low-carbohydrate, ketogenic diet versus a low-glycemic index diet on glycemic control in type 2 diabetes mellitus. Nutr Metab. 2008;5:36. Crossref
16. Wolever TM. Carbohydrate and the regulation of blood glucose and metabolism. Nutrition reviews. 2003;6:S40-8. Crossref https://doi.org/10.1301/nr.2003.may.s40-s48

17. Gannon MC, Nuttall FQ. Effect of a High-Protein, Low-Carbohydrate Diet on Blood Glucose Control in People With Type 2 Diabetes. Diabetes. 2004;53(9):2375. Crossref

18. Boden G, Sargrad K, Homko C, Mozzoli M, Stein TP. Effect of a low-carbohydrate diet on appetite, blood glucose levels, and insulin resistance in obese patients with type 2 diabetes. Ann Intern Med. 2005;142(6):403-11. Crossref

19. Yamada Y, Uchida J, Izumi H, Tsukamoto Y, Inoue G, Watanabe Y, et al. A non-calorie-restricted low-carbohydrate diet is effective as an alternative therapy for patients with type 2 diabetes. Intern Med. 2014;53(1):13-9. Crossref

20. Wilcox G. Insulin and insulin resistance. ClinBiochem Rev. 2005;26(2):19-39. Website

21. Ludwig DS, Ebbeling CB. The Carbohydrate-Insulin Model of Obesity: Beyond "Calories In, Calories Out". JAMA Intern Med. 2018;178(8):1098-103. Crossref

22. Elhayany A, Lustman A, Abel R, Attal-Singer J, Vinker S. A low carbohydrate Mediterranean diet improves cardiovascular risk factors and diabetes control among overweight patients with type 2 diabetes mellitus: a 1-year prospective randomized intervention study. Diabetes Obes Metab. 2010;12(3):204-9. Crossref

23. Grundy SM, Neeland IJ, Turer AT, Vega GL. Waist circumference as measure of abdominal fat compartments. J Obes. 2013;2013:454285. Crossref

24. Huntriss R, Campbell M, Bedwell C. The interpretation and effect of a low-carbohydrate diet in the management of type 2 diabetes: a systematic review and meta-analysis of randomised controlled trials. Eur J Clin Nutr. 2018;72(3):311-25. Crossref