ARTICLE

Carbohydrate counting in type 1 diabetes mellitus: dietitians' perceptions, training and barriers to use

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Objectives A study was undertaken to determine the perceptions, training and barriers regarding the use of carbohydrate counting in the dietary management of type 1 diabetes mellitus (T1DM) among dietitians in KwaZulu-Natal (KZN).
Design A cross-sectional, descriptive study was conducted.
Setting Dietitians who were registered with the Health Professions Council of South Africa (HPCSA), and working in the province of KZN at the time of the study, were invited to participate.
Methods Data were collected using a self-administered electronic questionnaire distributed through SurveyMonkey, an Internet-based survey programme.
Results Dietitians agreed that carbohydrate counting was a useful dietary management approach for diabetes ($p < 0.05$) and that it was essential to manage T1DM ($p < 0.05$). However, they felt it was a difficult concept for patients with T1DM to understand ($p = 0.001$) and teaching it to patients was time consuming ($p < 0.05$). Although dietitians believed that there was a strong evidence base for teaching carbohydrate counting to patients with T1DM ($p < 0.05$), they indicated a need for further training or education in it ($p < 0.05$). Barriers to using carbohydrate counting included a lack of training, confidence and experience, financial resources, time, blood glucose records and poor patient motivation and patient illiteracy ($p < 0.05$).
Conclusions Overall, dietitians who participated in the study had a positive perception towards the use of carbohydrate counting in the management of T1DM. However, further training needs to be addressed for carbohydrate counting to be used with confidence by dietitians in KZN to optimize their management of T1DM.

Keywords barriers, carbohydrate counting, dietary management, dietitians, perceptions, training, type 1 diabetes mellitus

Introduction

Carbohydrate counting is one of the dietary management approaches that can be used in the management of type 1 diabetes mellitus (T1DM).[1] It can be used by those with T1DM who use either multiple daily injections (basal bolus regime) or continuous subcutaneous insulin infusion to manage their diabetes.[1] It focuses on carbohydrates as the primary macronutrient affecting postprandial glycaemic response[1] and is used to adjust insulin dose levels according to the carbohydrate content of the meal.[2] With carbohydrate counting, the patient is made aware of the effect of carbohydrate-containing foods on blood glucose levels.[3] Patients are taught to quantify the amount of carbohydrates by visualisation using education tools like plate models or hand portions. They are then taught to give the correct amount of insulin depending on the portion of carbohydrate, to prevent hyper- and hypoglycaemia and maintain normal blood glucose levels.[4] The National Institute for Health and Care Excellence (NICE) guidelines recommend that carbohydrate counting should be offered to all adults with T1DM as part of self-management structured education.[5] For those who are not able to gain access to such structured education groups, it is recommended that it be given on a one-on-one basis.[5] Carbohydrate counting has been shown to improve glycaemic control as well as quality of life, but must be taught by someone who has clinical expertise in this field, such as an experienced registered dietitian.[6]

Carbohydrate counting has been known since the 1920s[7] and was one of the selected nutrition interventions used together with intensive insulin therapy to attain normoglycaemia in subjects who participated in the Diabetes Control and Complications Trial (DCCT) trial.[8] This method was effective in achieving glycaemic control as well as allowing for flexibility with food choices.[1,9] A meta-analysis of the current literature on the effectiveness of carbohydrate counting in comparison with other diet methods showed that carbohydrate counting resulted in a significant reduction in glycosylated haemoglobin (HbA_{1c}). In the studies analysed, 773 participants contributed to the data on HbA_{1c}. This was shown for the adult population group and not children and young people, possibly because adults are more likely to learn and apply knowledge on carbohydrate counting.[10] According to Gillespie et al.,[11] there are three levels of carbohydrate counting. Level 1 is the basic level of carbohydrate counting that can be taught to patients with T1DM and type 2 diabetes mellitus (T2DM). Level 2 is for patients who have mastered level 1 and desire further skills pertaining to blood glucose patterns and food intake. Level 3 is designed primarily for people with T1DM on intensive insulin regimes who use insulin-to-carbohydrate ratios.[11]

Carbohydrate counting is recommended as standard care for the management of T1DM in the United States of America (USA) and the United Kingdom (UK).[12,13] The American Diabetes Association (ADA) recommends that carbohydrate counting should form part of the standard care for patients with T1DM.[12,14] There is a lack of published data on the use of carbohydrate counting in T1DM in South Africa (SA).[15]

There are no published data on the perceptions of dietitians in KZN towards the use of carbohydrate counting in the dietary management of T1DM and whether they have been adequately trained in its use. It is also not known if there are any barriers

that prevent dietitians from using carbohydrate counting to manage T1DM. To fill this research gap, this study aimed to determine the perceptions, training and barriers regarding the use of carbohydrate counting in the dietary management of T1DM among dietitians in KZN. This study was conducted in KZN as the crude prevalence of diabetes in this province is approximately 34.1%.[16] In addition, a 12.9% prevalence of diabetes has been reported in Durban, KZN, which is one of the highest for sub-Saharan Africa.[17]

Methods

Study design
A cross-sectional descriptive study was conducted.

Study population
The study population included dietitians who were registered with the Health Professions Council of South Africa (HPCSA) and working in government and private settings within the KZN province at the time of the study. Only dietitians who were involved in the dietary management of patients with T1DM at the time of the study were included. Dietitians completing community service at the time of the study were excluded due to limited exposure to practice. The National Institute for Health Research (NHIR) gave permission for the KZN Department of Health (DOH) to be approached so that those dietitians employed by the DOH could be invited to participate in the study. Additional participants were recruited via the Association for Dietetics in South Africa (ADSA) in KZN. A total of 173 ADSA members and approximately 100 DOH-employed dietitians were eligible to participate in the study.

Self-administered electronic questionnaire
A self-administered questionnaire was developed for this study and was used electronically to collect data to meet the study objectives. Accessibility to the Internet was a likely characteristic of the study population and accessing an electronic questionnaire would not be difficult. A web-based survey tool, Survey-Monkey, was used to distribute and manage the questionnaire. The ADA, International Society for Pediatric and Adolescent Diabetes (ISPAD), Diabetes UK and SEMDSA guidelines for the management of diabetes were used to develop the questionnaire.[12,13,15,18] The levels of CHO counting were not defined in the questionnaire as it was assumed that not all dietitians would be aware of the levels. The questionnaire was based on carbohydrate counting in general. Perceptions towards carbohydrate counting were determined by the use of a six-point Likert scale of agreement. The agreement scale was coded as follows: Strongly disagree = 1; Disagree = 2; Slightly disagree = 3; Slightly agree= 4; Agree = 5; Strongly agree = 6. A central score of 3.5 was used to test the agreement score. An average agreement score that was significantly different from 3.5 indicated a significant result. A mean score greater or less than 3.5 meant that there was significant agreement/ disagreement.

An expert panel consisting of four dietitians reviewed the questionnaire. All members of the panel had a special interest in diabetes and carbohydrate counting and were working in the private, public or academic sectors at the time of the study. The questionnaire was assessed for appropriateness and comprehensiveness by the expert panel to ensure that the study objectives were met. Revisions were made to the questionnaire according to their recommendations. The study supervisor and statistician checked that the questions answered the study objectives and flowed logically without any leading, ambiguous or confusing questions. Clear and detailed instructions were provided to the subjects while the questionnaires were being completed and questions could not be skipped, which helped to ensure consistency. The questionnaire was validated by conducting a pilot study using dietitians working outside KZN prior to the main study. Eleven dietitians working in both the public and private sectors were invited to participate in the pilot study. The pilot study aimed to correct any errors in the questionnaire, to calculate the time needed for completion of the questionnaire and to make sure that the questions were easy to understand and unambiguous. An email with a link to the SurveyMonkey questionnaire was sent out to the pilot study participants. The consent form and study information were attached for review as well as an option for participants to add comments at the end of the questionnaire. Problems regarding flow and ambiguity of the questions and errors found in the questionnaire were corrected prior to the main study.

Data collection
An email with a link to the questionnaire was sent to all the ADSA members in KZN. The survey was uploaded on the KZN DOH intranet under the surveys tab, where the DOH dietitians could access the survey. Permission was obtained from the Nutrition Directorate to email the dietitians at the separate DOH hospitals to alert them to the survey on the intranet. The questionnaire was available between November 2018 and February 2019.

Data analysis
Data from the questionnaires on SurveyMonkey were directly exported onto a Microsoft Excel spreadsheet (Microsoft Corp, Redmond, WA, USA). The exported data were coded and checked for errors by the researcher. A research assistant checked the data for errors before they were analysed by a statistician using the Statistical Package for Social Sciences (SPSS) version 26.0 (IBM Corp, Armonk, NY, USA). Descriptive statistics, chi-square/goodness-of-fit test, binomial test, one-sample t-test, independent samples t-test, analysis of variance (ANOVA), Pearson's/Spearman's correlation and the chi-square test of independence were used to analyse the data. A p-value of < 0.05 was statistically significant.

Ethical considerations
The Humanities and Social Science Ethics Committee of the University of KwaZulu-Natal (Reference number HSS/1612/018M) granted ethical approval for the study. The NHIR on behalf of KZN DOH approved the study to be conducted on dietitians employed by the KZN DOH. The KZN branch of ADSA granted permission for their members to be contacted regarding the study. A consent letter attached to the email informed the dietitians that by opening the link to the survey they were giving consent to participate; however, they had the option to leave the survey at any time.

Results

Sample characteristics
Sample characteristics are displayed in Table 1. Just under half of the sample size were between 26 and 35 years of age. The largest portion of dietitians (78.3%; $n = 54$) had attended the University of KwaZulu-Natal and 62.3% ($n = 43$) held a Post Graduate Diploma in Dietetics as their highest qualification (Table 1). Some 55% ($n = 38$) of the participants specified that

Table 1: Sample characteristics (n = 69)

Characteristic	Category	n (%)
Age (years) (n = 69)	20–25	9 (13.0)
	26–35	33 (47.8)
	36–45	21 (30.4)
	46–55	4 (5.8)
	56–65	2 (2.9)
University attended (n = 69)	North-West University	2 (2.9)
	University of Cape Town	2 (2.9)
	University of KwaZulu-Natal	54 (78.3)
	University of Stellenbosch	6 (8.7)
	University of Pretoria	1 (1.4)
	University of the Western Cape	2 (2.9)
	Other	2 (2.9)
Highest qualification (n = 68)	BSc Diet (Honours)	9 (13.0)
	BSc Diet	5 (7.2)
	PGDip Diet	43 (62.3)
	MSc Diet	10 (14.5)
	PhD	1 (1.4)
Sector of employment (n = 69)	Private	38 (55.1)
	Public	25 (36.2)
	Both private and public	6 (8.7)
Area of employment (n = 69)	Rural	4 (5.8)
	Semi-rural	11 (15.9)
	Urban	54 (78.3)
Number of years registered with the Health Professions Council of South Africa (n = 69)	1–10 years	42 (60.9)
	11–20 years	18 (26.1)
	21–30 years	6 (8.7)
	> 31 years	3 (4.3)
Dietary advice given to patients with T1DM (n = 62)	Yes	53 (76.8)
	No	9 (13.0)

they worked in the private sector and 36.2% (n = 25) indicated that they worked in the public sector. Just under 9% (n = 6) worked in both the public and private sectors. The majority of the dietitians (78%, n = 54) indicated that they worked in an urban area, while 15.9% (n = 11) and 5.8% (n = 4) worked in semi-rural and rural areas, respectively. The average amount of years registered with the HPCSA was 10.9 and 60% (n = 42) were registered for between 1 and 10 years. About 77% (n = 53) of participants indicated that they gave dietary advice to patients with T1DM.

Dietitians' perceptions on the use of carbohydrate counting in the dietary management of T1DM

Respondents were asked to indicate their perceptions of carbohydrate counting by indicating their level of agreement with statements using a six-point Likert scale. A one-sample t-test was used to test for significant agreement or disagreement with the statements. Dietitians agreed that carbohydrate counting was useful as a dietary management approach ($p < 0.05$) and that it was an essential part of the dietary management of T1DM ($p < 0.05$) (Table 2). Dietitians also agreed that carbohydrate counting was a difficult concept for patients with

T1DM to understand ($p = 0.001$) and that teaching patients how to carbohydrate count was time consuming ($p < 0.05$). There was significant agreement among the dietitians that carbohydrate counting could only be taught alongside intensive insulin therapy or multiple daily injections ($p = 0.025$) and that all patients with diabetes could be taught some form of carbohydrate counting ($p < 0.05$). Dietitians believed that there was a strong evidence base for teaching carbohydrate counting to patients with T1DM ($p < 0.05$) (Table 2).

Training in carbohydrate counting

Dietitians were asked to indicate their level of agreement with statements about their training in carbohydrate counting using a six-point Likert scale. Dietitians significantly disagreed with the statement that they received adequate training in carbohydrate counting in their undergraduate degree ($p < 0.05$) and that their undergraduate training adequately prepared them for educating a patient with T1DM ($p = 0.006$) (Table 3). Dietitians significantly disagreed with the statement that they had received specialised training in the dietary management of diabetes ($p = 0.002$) and strongly agreed that they required further training or education in the use of carbohydrate counting to manage patients with T1DM ($p < 0.05$). Dietitians strongly agreed that they would attend a teaching/training session in the use of carbohydrate counting, if it were available to them ($p < 0.05$). They strongly agreed that they would find it useful to use an online resource/tool when teaching carbohydrate counting to their patients/clients (e.g. mobile application, web-based calorie counting tool) ($p < 0.05$) (Table 3).

Barriers to the use of carbohydrate counting

Respondents were asked to indicate their level of agreement regarding barriers to the use of carbohydrate counting in the dietary management of diabetes, using a six-point Likert scale. Dietitians significantly agreed that the following were barriers to their use of carbohydrate counting in the management of diabetes: lack of financial resources ($p = 0.001$), lack of training or knowledge of dietitians, a lack of experience in the practice of carbohydrate counting, a lack of confidence to use carbohydrate counting, patient illiteracy, a lack of time, a lack of blood glucose records and a lack of patient motivation ($p < 0.05$) (Table 4).

Discussion

This study aimed to determine the perceptions, training and barriers regarding the use of carbohydrate counting in the dietary management of T1DM among dietitians in KZN. Overall, the dietitians who participated had a positive perception on the use of carbohydrate counting in the dietary management of T1DM. They agreed that carbohydrate counting was a useful dietary management approach and that it was an essential part of the dietary management of T1DM. However, dietitians acknowledged that carbohydrate counting was a difficult concept for patients with T1DM to understand and that teaching patients how to carbohydrate count was time consuming. Diabetes educators and providers are known to tailor recommendations and guidelines to the individual needs of their patients. Part of this process includes assessing and addressing the patient's numeracy skills and level of health literacy, to provide the best diabetes care.[19] According to a study conducted by White et al.,[19] patients with a grade nine level of numeracy skills struggled to calculate the total carbohydrate content in a container of chips.[19] Even identifying the correct dosages on an insulin syringe proved difficult for

Table 2: Dietitians' perceptions on the use of carbohydrate counting

Factor	Strongly disagree	Disagree	Slightly disagree	Slightly Agree n (%)	Agree	Strongly agree	Mean agreement score	p-value*
Carbohydrate counting is useful as a dietary management approach	0 (0)	2 (2.9)	2 (2.9)	9 (13.0)	30 (43.5)	14 (20.3)	5.02	**< 0.05**
I believe that carbohydrate counting is an essential part of the dietary management of type 1 diabetes mellitus	2 (2.9)	1 (1.4)	2 (2.9)	8 (11.6)	34 (49.3)	10 (14.5)	4.91	**< 0.05**
I believe that carbohydrate counting is a difficult concept for patients with type 1 diabetes to understand	0 (0)	4 (5.8)	12 (17.4)	18 (26.1)	15 (21.7)	6 (8.7)	4.07	**0.001**
Teaching patients how to carbohydrate count is time consuming	0 (0)	2 (2.9)	2 (2.9)	17 (24.6)	21 (30.4)	13 (18.8)	4.73	**< 0.05**
Carbohydrate counting can only be taught alongside intensive insulin therapy or multiple daily injections	2 (2.9)	9 (13.0)	11 (15.9)	10 (14.5)	14 (20.3)	9 (13.0)	3.95	**0.025**
I believe all patients with diabetes can be taught some form of carbohydrate counting	1 (1.4)	2 (2.9)	1 (1.4)	8 (11.6)	26 (37.7)	17 (24.6)	4.96	**< 0.05**
I believe that there is a strong evidence base for teaching carbohydrate counting to patients with type 1 diabetes	0 (0)	1 (1.4)	1 (1.4)	18 (26.1)	23 (33.3)	12 (17.4)	4.79	**< 0.05**

*One-sample *t*-test; *p*-values in bold are statistically significant.

Table 3: Training in carbohydrate counting

Factor	Strongly disagree	Disagree	Slightly disagree	Slightly agree n (%)	Agree	Strongly agree	Mean agreement score	p-value*
I received adequate training in carbohydrate counting as an undergraduate student in my degree	16 (23.2)	17 (24.6)	6 (8.7)	9 (13.0)	7 (10.1)	2 (2.9)	2.65	**< 0.05**
My undergraduate training adequately prepared me for educating a patient with type 1 diabetes mellitus	7 (10.1)	14 (20.3)	12 (17.4)	19 (27.5)	4 (5.8)	1 (1.4)	3.04	**0.006**
I am well equipped to teach patients to carbohydrate count	4 (5.8)	9 (13.0)	10 (14.5)	16 (23.2)	16 (23.2)	2 (2.9)	3.65	0.401
I require further training or education in the use of carbohydrate counting as a dietary management approach, to manage patients with type 1 diabetes mellitus	0 (0)	3 (4.3)	4 (5.8)	11 (15.9)	18 (26.1)	21 (30.4)	4.88	**< 0.05**
I would attend a teaching/ training session in the use of carbohydrate counting if it was available to me	0 (0)	1 (1.4)	1 (1.4)	4 (5.8)	19 (27.5)	32 (46.4)	5.40	**< 0.05**
I would find it useful to use an online resource/tool when teaching carbohydrate counting to my patients/clients (e.g. mobile application, web-based calorie counting tool)	0 (0)	2 (2.9)	4 (5.8)	7 (10.1)	18 (26.1)	26 (37.7)	5.09	**< 0.05**
I have had specialised training in the dietary management of diabetes	13 (18.8)	18 (26.1)	7 (10.1)	11 (15.9)	2 (2.9)	6 (8.7)	2.81	**0.002**

*One-sample *t*-test; *p*-values in bold are statistically significant.

Table 4: Barriers to the use of carbohydrate counting

Factor	Strongly disagree	Disagree	Slightly disagree	Slightly agree n (%)	Agree	Strongly agree	Mean agreement score	p-value*
Lack of financial resources	0 (0)	11 (15.9)	7 (10.1)	11 (15.9)	19 (27.5)	9 (13.0)	4.14	**0.001**
Lack of training or knowledge of dietitians	0 (0)	6 (8.7)	5 (7.2)	11 (15.9)	25 (36.2)	10 (14.5)	4.49	**< 0.05**
Dietitians lack experience in the practice of carbohydrate counting	0 (0)	5 (7.2)	8 (11.6)	7 (10.1)	22 (31.9)	15 (21.7)	4.60	**< 0.05**
Dietitians lack the confidence to use carbohydrate counting	2 (2.9)	3 (4.3)	5 (7.2)	15 (21.7)	21 (30.4)	11 (15.9)	4.46	**< 0.05**
Patient illiteracy	2 (2.9)	2 (2.9)	4 (5.8)	13 (18.8)	16 (23.2)	20 (29.0)	4.74	**< 0.05**
Lack of time	0 (0)	5 (7.2)	9 (13.0)	17 (24.6)	15 (21.7)	11 (15.9)	4.32	**< 0.05**
Lack of blood glucose records	1 (1.4)	2 (2.9)	4 (5.8)	12 (17.4)	24 (34.8)	14 (20.3)	4.72	**< 0.05**
Lack of patient motivation	1 (1.4)	3 (4.3)	5 (7.2)	13 (18.8)	18 (26.1)	17 (24.6)	4.67	**< 0.05**

*One-sample *t*-test; *p*-values in bold are statistically significant.

some participants with low numeracy skills.[19] Because level two and level three carbohydrate counting entails more advanced carbohydrate counting skills, such as reading nutritional labels, estimating portion sizes and weighing foods, this reinforces the perception that carbohydrate counting is a difficult concept to understand.[7] Literacy levels and numeracy skills could therefore also play a role in the time taken for patients to be taught how to carbohydrate count. This is because patients with lower literacy and numeracy skills require more intensive, longer counselling sessions in order for them to grasp concepts such as the estimation of portion sizes and reading nutritional labels correctly.

There was significant agreement among the dietitians that carbohydrate counting could only be taught alongside intensive insulin therapy or multiple daily injections and that all patients with diabetes on insulin therapy could be taught some form of carbohydrate counting. Dietitians believed that there was a strong evidence base for teaching carbohydrate counting to patients with T1DM. Although the ADA recommend carbohydrate counting, there are no South African guidelines that discuss carbohydrate counting in the context of T1DM. Although dietitians had a positive perception on the use of carbohydrate counting, they identified a need for further training in its use. Dietitians strongly agreed that they required further training or education in the use of carbohydrate counting as a dietary management approach to manage patients with T1DM and were willing to attend a teaching/training session in the use of carbohydrate counting, if it was to be available to them. This finding motivates towards training in the use of carbohydrate counting to be made available to dietitians. Other dietitians, who have a special interest in the field of diabetes or have received additional training in the area of carbohydrate counting, could deliver this training. Very few indicated that they had specialised training in diabetes management, which also suggests that there is a need for further training in diabetes management. Dietitians felt that they did not receive adequate training in carbohydrate counting in their undergraduate degree. This suggests that universities which offer an undergraduate dietetics degree should consider increasing the amount of training offered in carbohydrate counting.

In this study, the dietitians indicated that the following were the main barriers to the use of carbohydrate counting: patient

illiteracy, lack of blood glucose records and a lack of patient motivation. Other authors have reported similar barriers to carbohydrate counting, which include difficulties experienced by patients in understanding the concept, the time and effort that it takes for patients to count the carbohydrate content at each meal and the availability of adequately trained healthcare providers to teach patients.[7]

Effective communication between healthcare professionals and patients was seen as a predictor of better diabetes care and outcomes, according to a study that investigated barriers to diabetes management.[20] Low health literacy can often be confused with a lack of patient motivation and this could be addressed by providing better support for patients through patient-centred education.[21] This study highlights the need for further training in the area of carbohydrate counting for dietitians, starting at an undergraduate level. A larger study incorporating all dietitians in South Africa should be conducted and participants should be recruited from both the private and public sectors.

Study limitations and recommendations
Not all dietitians who work in KZN are members of ADSA or work for the DOH. Therefore, it is possible that some dietitians in KZN were not invited to participate in the study. The sample was therefore not a true representation of all the dietitians in the province of KZN and this prevents generalised conclusions from being made. Due to the online nature of the survey method, it is possible that any participant who answered it was an unintended recipient of the survey. It was also possible that the participant looked up the answers to the survey or requested that someone else answer the questions for them. All participants in the study took part voluntarily. The fact that the study relied on volunteers could have created bias and affected the size of the sample. It was possible that by addressing T1DM specifically in the study, this may have limited the number of responses received. A lack of training was identified in this study. To rectify this, universities should add carbohydrate counting to their curriculum on the dietary management of diabetes. Dietitians who have specialised in the field of diabetes or have received additional training in the area of carbohydrate counting could deliver this training to undergraduate students. Continuous professional development (CPD) accredited courses should be made available to dietitians

who wish to become more specialised in this area, either as a standalone course or as part of a current course offered to healthcare professionals. Furthermore, an increase in the availability of online resources and training could possibly increase the use of carbohydrate counting amongst dietitians. Future studies should be conducted across all provinces in South Africa and should include all dietitians who use carbohydrate counting to manage T1DM.

Conclusion

Dietitians from KZN who participated in the study had a positive perception towards the use of carbohydrate counting in the dietary management of T1DM. However, they indicated that they received inadequate training in carbohydrate counting in their undergraduate degree and required further training in the use of carbohydrate counting. Dietitians were willing to receive more training in carbohydrate counting and to apply it to patient care. A lack of financial resources, training or knowledge of dietitians, experience in the practice of carbohydrate counting, confidence to use carbohydrate counting, time, blood glucose records and patient motivation and patient illiteracy were barriers that prevented dietitians from using carbohydrate counting to manage T1DM. These barriers should be addressed to improve the use of carbohydrate counting in the management of T1DM among dietitians in KZN.

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