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Carbohydrate counting of food

An essential element in the treatment of diabetes type 1 is improved by a new tool: the Nutri-Learn buffet

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Summary

QUESTIONS UNDER STUDY: Carbohydrate counting is a principal strategy in nutritional management of type 1 diabetes. The Nutri-Learn buffet (NLB) is a new computer-based tool for patient instruction in carbohydrate counting. It is based on food dummies made of plastic equipped with a microchip containing relevant food content data. The tool enables the dietician to assess the patient's food counting abilities and the patient to learn in a hands-on interactive manner to estimate food contents such as carbohydrate content.

METHODS: Multicentre randomised controlled trial in 134 patients with type 1 diabetes comparing the use of the Nutri-Learn buffet in determining and improving ability to estimate the carbohydrate content of food with the use of conventional counselling tools (i.e. pictures and tables).

RESULTS: The NLB group showed significantly better carbohydrate estimation values than the control group. In particular, there was a significant improvement in estimation of starches, fruits and sweets. The NLB was preferred by patients and dieticians in that rating of carbohydrate was closer to reality than the use of conventional tools, and since the tool has a play element, is interactive and adjustable, and can be used with only minimal knowledge of a specific language.

CONCLUSIONS: Adjustment of preprandial insulin doses to the amounts of dietary carbohydrates ingested during the subsequent meal resulted in improved metabolic control in previous studies. The present study demonstrated that the new tool (Nutri-Learn buffet) improved teaching and learning of carbohydrate counting. In addition, it allowed an objective assessment of the carbohydrate counting skills of patients by the dietician. The findings therefore suggest that the tool is helpful in nutritional counselling of patients with diabetes mellitus.

Key words: *insulin therapy; carbohydrates; dietary treatment; education; assessment; glycaemic control; diabetes type 1*

Introduction

Medical nutrition therapy in type 1 diabetes is an important factor in managing glucose control and thereby glycaemic outcomes [1]. Meal-planning strategies for type 1 diabetes emphasise the relationship between prandial insulin dose selection and the anticipated amount of carbohydrate to be consumed. Although no method for carbohydrate estimation has proved superior in the management of subjects with type 1 diabetes, carbohydrate counting has become a principal strategy for children [2, 3] and adults [4–6] with type 1 diabetes.

The DAFNE trial showed that skill training promoting dietary freedom combined with flexible, intensive insulin management improved quality of life and glycaemic control in patients with type 1 diabetes without increasing the risk of severe hypoglycaemia or cardiovascular complications [7].

Today meals or foods are increasingly consumed outside the home where weighing of food is not possible. Knowledge of the nutritional content of foods, and in particular their carbohydrate content, is therefore of major importance. Learning to estimate the carbohydrate content of food has usually been based on foodstuff tables or pictures. Pictures are not 1:1 proxies of real food, and their view is two-dimensional. We therefore developed a tool with realistic plastic food dummies and a computer based system displaying estimated and real carbohydrate content of foods and the difference between them (the Nutri-Learn buffet). It could thereby be used in a hands-on manner and served two purposes: first, dieticians were able to assess the patient's knowledge, and second, the patient learned to estimate carbohydrates of various foods in a play mode and without knowledge of a specific language.

The present multicentre randomised controlled trial aimed to assess the use of the Nutri-Learn buffet in dietary counselling to assess and improve the estimation of food carbohydrate content compared to the use of conventional tools (pictures or tables).

Materials and methods

Subjects

The study protocol was approved by the Human Ethics Committee of the University of Basel. Seven diabetes clinics in Switzerland participated (Basel (2), Bern, Luzern, St. Gallen, Olten, Zurich). Physicians at each site encouraged patients with type 1 diabetes to participate and give their informed consent. They were required to fulfil the following criteria: treatment with basal-bolus insulin therapy; performing at least 3 glucose measurements per day; diabetes duration of >12 months; basic dietary knowledge and relatively stable metabolic control. They had to understand the German language in order to fill out the Quality of Life questionnaires. 144 subjects agreeing to participate were randomly assigned by a random number generator to either the Nutri-Learn buffet (NLB) group or to the control group using conventional counselling tools. Five subjects attended only the first consultation (2 in the control group and 3 in the NLB group) and were excluded from the analyses. Five subjects in the NLB group and 3 controls did not participate in the follow-up tests, leaving a total of 134 subjects for analysis.

Procedures

Patients in both groups attended 3 visits at a 3-week interval. Each visit lasted about one hour. The Nutri-Learn buffet was manufactured (http://www.semafor.ch/) using plastic dummies equipped with microchips with stored information on the food content and RFID (radio-frequency identification) technology, allowing identification of the data on selected foods (fig. 1). The dummies were placed in the reception area of an antenna which read the corresponding data into a PC using a USB interface. In the NLB group carbohydrate counting exercises were performed using many different realistic dummies of foodstuffs. Specifically, the patients entered the estimated carbohydrate content of the selected foodstuffs of a meal on a tray into the PC. The programme analysed the patient's performance by showing estimated and true results of the carbohydrate content of the selected foods. The NLB could also be used to estimate the quantity of other food components (e.g. calorie or fat content), but this was not assessed in the present study. Teaching materials used in the conventional group were food pictures or tables. All patients were encouraged to practice carbohydrate counting at home.

Figure 1

The Nutri-learn buffet with examples of food dummies.

Parameters

Before and at 3 and 6 months after beginning the intervention, the patients' ability in carbohydrate counting was assessed by calculating the differences between the real and estimated carbohydrate content of various foodstuffs. HbA1c, mean blood glucose, body mass index, frequency of hypoglycaemia and quality of the consultations rated by the patients and by the dieticians were also recorded. To assess the quality of the consultation, patients and dieticians rated 5 items reflecting efficiency, enjoy, proximity to reality, increase in certainty, and increase in knowledge on a 6-point Likert scale from 1 (not at all; low quality) to 6 (exactly; high quality).

Standardised questionnaires were used to assess diabetes specific quality of life (ADDQoL) [2]. The patients also completed the WHO-5 Well-Being Questionnaire validated for the quality of care in diabetic patients [8].

The WHO-5 Well-Being Index is a rating scale on quality of life in patients suffering from diabetes. It covers positive mood, vitality and general interests. Each of the five items is rated on a 6-point Likert scale from 0 (not present) to 5 (constantly present). Thus, higher scores mean greater wellbeing.

Statistical analyses

Repeated measures ANOVA was used to investigate the effect of treatment (between subjects factor (F): NLB group vs. control group) and time (within subjects factors: baseline vs. 6-month follow-up). Contrasts were constructed *a priori* for comparisons of T1 (baseline, before intervention) vs. T3 (6 months after intervention). Two-tailed Student t-tests for independent samples were used to examine the differences between the two groups at T3. Including gender, duration of diabetes, baseline HbA1c and time lag since last counselling by a dietician as covariates in the model did not have a significant effect on the results. Hence covariates were not included in the final model. Data are means ± 1 standard deviation (SD). Calculations were performed using SPSS (Version 15.0 for Windows, SPSS Inc., Chicago, Illinois, USA).

Results

Baseline characteristics

Baseline characteristics of the 134 subjects completing the study showed no significant differences (table 1).

Effect of the interventions

HbA1c, mean plasma glucose (MPG), frequency of hypoglycaemia, body mass index and units of insulin per kg bodyweight were not influenced by the intervention (table 2).

Table 3 shows that at baseline, the carbohydrate counting abilities in the two groups were similar (differences between real and estimated carbohydrate content of meals). Three consultations with the NLB resulted in significantly better carbohydrate estimation values than 3 consultations in the control group. In particular, there was a significant improvement in estimation of starches, fruits and sweets.

Table 4 shows the rating of the quality of counselling by the patients; it indicated that the NLB was closer to reality than

Table 1: Baseline characteristics (means ± SD).

	NLB Group (n = 66)	Control Group (n = 65)
Sex (female / male; no of subjects)	36 / 30	33 / 32
Age (years)	39 ± 14.7	41 ± 14.5
Diabetes duration (yrs)	17.7 ± 13.5	17.7 ± 12.9
Body mass index (kg/m^2)	23.9 ± 4.2	25.6 ± 4.3
HbA1c (%)	7.5 ± 1.4	7.5 ± 1.1
Mean plasma glucose (MPG; mmol/l) (last 20 measurements before consultation)	8.6 ± 2.2	8.9 ± 1.9
Glucose measurements/day	4.4 ± 1.7	4.1 ± 1.6
Insulin (units/kg BW/day)	0.62 ± 0.22	0.62 ± 0.22
Last consultation with dietitian (years ago)	6.5 ± 0.8	5.0 ± 0.6

Table 2: Body mass index and glycaemic control (means ± SD).

	T1 (baseline)	T3 (after 6 months)	Contrast T3 vs T1; time effect; F, p	Time x group interaction; F, p
BMI (kg/m^2)				
NLB	23.92 ± 4.21	24.03 ± 4.01	F(1,132) = 3.03	F(1,132) = 0.26
Controls	25.67 ± 4.13	25.87 ± 4.32	p = 0.08	p = 0.61
HbA1c (%)				
NLB	7.53 ± 1.44	7.39 ± 1.23	F(1,131) = 1.94	F(1,131) = 0.25
Controls	7.47 ± 0.96	7.40 ± 0.88	p = 0.17	p = 0.62
MPG (mmol / L) (last 20 measurements)				
NLB	8.62 ± 2.18	8.64 ± 1.79	F(1,132) = 0.71	F(1,132) = 0.86
Controls	8.96 ± 1.93	8.65 1.91	p = 0.40	p = 0.36
No. of glucose readings <3.9 mmol/L per week				
NLB	3.01 ± 2.33	2.75 ± 2.02	F(1,132) = 3.02	F(1,132) = 0.21
Controls	3.06 ± 2.33	2.61 ± 1.94	p = 0.09	p = 0.65
Insulin (U/kg BW/d)				
NLB	0.62 ± 0.22	0.62 ± 0.21	F(1,132) = 0.38	F(1,132) = 0.64
Controls	0.65 ± 0.22	0.63 ± 0.19	p = 0.54	p = 0.43

Table 3: Ability to estimate carbohydrates (difference between estimated and real carbohydrate content of dummies in gr; means ± SD).

	T1 (baseline)	T3 (after 6 months)	Contrast T3 vs T1; time effect; F*, p	Time x group interaction; F, p	Difference between NLB and controls at T3; t**; p
All food groups (below)					
NLB	130.4 ± 52.2	87.6 ± 32.7	F(1,128) = 106.2	F(1,128) = 4.45	t = 2.46
Controls	129.7 ± 41.5	101.4 ± 32.3	P <0.0001	p = 0.04	p = 0.015
Starch					
NLB	23.0 ± 14.0	14.4 ± 9.6	F(1,129) = 26.26	F(1,129) = 2.19	t = 3.02
Controls	24.1 ± 13.3	19.3 ± 9.3	P <0.0001	p = 0.15	p = 0.003
Alcohol					
NLB	20.4 ± 21.4	8.1 ± 8.2	F(1,131) = 64.35	F(1,131) = 1.93	t = 0.39
Controls	16.2 ± 12.9	7.6 ± 6.9	P <0.0001	p = 0.17	p = 0.70
Fruits					
NLB	12.8 ± 8.1	9.0 ± 5.6	F(1,131) = 6.81	F(1,131) = 1.35	t = 2.92
Controls	14.5 ± 11.8	13.0 ± 9.7	p = 0.01	p = 0.25	p = 0.004
Sweets					
NLB	13.1 ± 13.8	5.8 ± 5.2	F(1,131) = 26.42	F(1,131) = 6.04	t = 2.22
Controls	10.4 ± 7.7	7.9 ± 5.3	p <0.0001	p = 0.02	p = 0.03
Menu (lunch)					
NLB	65.7 ± 32.1	49.8 ± 26.3	F(1,128) = 28.31	F(1,128) = 0.11	t = 1.56
Controls	71.0 ± 32.4	57.0 ± 26.8	P <0.0001	p = 0.75	p = 0.12

* ANOVA ** Student's t tests (see Methods)

conventional tools. Rating by the dieticians (table 5) indicated that the NLB improved counselling since the tools were closer proxies to reality than conventional tools.

Quality of life was not influenced by treatment or intervention (table 6).

Discussion

The present study demonstrates that subjects with type 1 diabetes assigned to the Nutri-Learn buffet group showed better ability to estimate the carbohydrate content of selected food items than patients instructed with conventional tools. In addition, patients and dieticians preferred the teaching sessions with the interactive Nutri-Learn buffet compared to counselling with conventional tools.

These findings are a practical illustration of previous suggestions that teaching carbohydrate counting by interactive exercises produced better behavioural [9, 10] and glycaemic [11] outcomes than the didactic strategies commonly used.

Subjects with type 1 diabetes need to know the carbohydrate content of foods to enable them to adjust insulin doses in order to benefit from flexible meal planning without deterioration of glycaemic control [12].

To correctly count carbohydrates it is necessary to know the exact food weight, but scales are rarely used in everyday life. The total amount of carbohydrate consumed is a strong predictor of the postprandial glycaemic response, and monitoring of total grams of carbohydrate remains a key strategy in achieving glycaemic control [13].

Proficiency in carbohydrate counting allows increased flexibility in meal planning and thus dietary freedom. This is an important consideration for quality of life in diabetics. The DAFNE Study Group (5) showed that a structured training course designed to maintain glucose control while permitting dietary freedom produced favourable effects on quality of life.

In our study counselling carbohydrate counting did not significantly influence quality of life either in the NLB group or in the control group. This may have been due to the fact that all patients in this study already had earlier counselling experience.

The better acceptance of the NLB tool by patients and dieticians compared to conventional tools is important for the attainment of educational goals in type 1 diabetes, since strategies preferred and used more frequently by dieticians were also perceived as more effective [14].

Intervention with the NLB did not significantly improve glycaemic control, since HbA1c, average self-measured plasma glucose levels and frequency of hypoglycaemia did not differ between the two groups. This could have been due to the fact that during the intervention the dieticians performing counselling did not systematically address the adaptation of insulin doses to changes in carbohydrate intake, and both groups were counting carbohydrates. This

Table 4: Rating of quality of counselling by the patients (scores 1-6; means ± SD)*.

	NLB group (n = 68)	Controls (n = 64)	p
Efficiency	5.21 ± 0.70	*5.11* ± 0.89	0.46
Enjoy	5.40 ± 0.63	*5.33* ± 0.84	0.50
Proximity to reality	5.34 ± 0.56	*4.73* ± 1.17	<0.001
Increase in certainty	5.15 ± 0.72	*5.13* ± 0.95	0.88
Increase in knowledge	5.34 ± 0.75	*5.13* ± 0.92	0.15
*1 = low quality; 6 high quality			

Table 5: Rating of quality of counselling by the dieticians (scores 1–6; means ± SD)*.

	NLB group (n = 69)	Control group (n = 64)	p
Efficiency	4.78 ± 8.02	*4.75* ± 0.74	0.58
Enjoy	5.33 ± 0.61	*5.27* ± 0.67	0.66
Proximity to reality	5.36 ± 0.57	*4.73* ± 1.03	<0.001
Increase in certainty	4.64 ± 0.89	*4.47* ± 0.76	0.19
Increase in knowledge	4.74 ± 0.80	*4.58* ± 0.75	0.12
*1 = low quality; 6 high quality			

Table 6: Quality of life and well-being (DqoL scores; means ± SD).

	T1 (baseline)	T3 (after 6 months)	Contrast T3 vs T1; time effect; F, p	Time x group interaction; F, p
DQoL General				
NLB	1.20 ± 0.90	1.14 ± 0.82	F(1,129) = 0.18	F(1,129) = 1.54
Controls	1.12 ± 1.10	1.25 ± 0.88	p = 0.67	p = 0.22
DQoL Freedom to eat (6 = bad quality, 1 = good quality)				
NLB	3.05 ± 2.59	2.32 ± 2.09	F(1.129) = 2.91	F(1,129) = 2.91
Controls	2.63 ± 2.63	2.63 (2.52)	p = 0.09	p = 0.09
DQoL Enjoyment of food				
NLB	0.88 ± 1.89	0.97 (2.11)	F(1,129) = 0.02	F(1,129) = 0.50
Controls	0.95 ± 2.00	0.82 (1.32)	p = 0.88	p = 0.48
WHO-5				
NLB	15.88 ± 4.45	15.92 (4.00)	F(1,129) = 0.02	F(1,129) = 0.07
Controls	15.95 ± 4.54	15.83 (3.58)	p = 0.90	p = 0.79

interpretation agrees with the findings by others, that improving dietary knowledge does not necessarily translate into better glycaemic control [15]. This can be achieved when both dietary knowledge and insulin dosing are improved [7, 12]. Furthermore, the DCCT showed that patients using carbohydrate counting and an algorithm to adjust insulin dosing on the basis of ingested carbohydrates had a significant reduction in HbA1c compared to patients not counting carbohydrates [16].

Furthermore, the patients participating in this study were already well controlled at baseline (low frequency of hypoglycaemias compared to other reports of intensive insulin therapy [17], and relatively low HbA1c values of approximately 7.5%).

Nevertheless, both groups showed a tendency to improvement of HbA1c during the study.

Average HbA1c values of patients with type 1 diabetes were in fact often higher than those in the present report: in the DAFNE trial, HbA1c at baseline was 9.3% [7], in the study of Bruttomesso et al. 9.9% [4] and in the study of Kalergis et al. 10.0% [18].

Hence it may have taken a longer time or more patients for the improvement in counting abilities to translate into metabolic benefits.

In conclusion, NLB represents a counselling tool which is liked by patients and dieticians. It permits training and assessment of knowledge of food content with realistic dummies. The tool is hands-on and interactive, and can be used without knowledge of a specific language. Training sessions with the NLB buffet can be performed by the patients alone, keeping records of the estimation results for later analysis by the dietician.

The use of the NLB can be extended to other foodstuffs and food components, such as fats, proteins or micronutrients. It has therefore great potential for more general use in dietary counselling.

Improving quantitative nutritional knowledge is an important factor in medical nutrition therapy [1]. Modern dietary habits are characterised by frequent eating outside the home and by consumption of industrially manufactured foods. Successful nutritional therapy allows dietary freedom combined with adequate glycaemic control. This will be achieved by using flexible insulin doses adjusted to ingested food, and in particular to the amount and type of dietary carbohydrates [12, 19, 20].

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References

1 American Diabetes Association. Nutrition Recommendations and Interventions for Diabetes: A position statement of the American Diabetes Association. Diabetes Care. 2007;30:S48–S65.

2 Bradley C, Speight J. Patient perceptions of diabetes and diabetes therapy: assessing quality of life. Diabetes Metab Res Rev. 2002;18(Suppl 3):S64–S69.

3 Kawamura T. The importance of carbohydrate counting in the treatment of children with diabetes. Pediatr Diabetes. 2007;8(Suppl 6):57–62.

4 Bruttomesso D, Pianta A, Crazzolara D, et al. Teaching and training programme on carbohydrate counting in Type 1 diabetic patients. Diabetes Nutr Metab. 2001;14:259–67.

5 Mann JI, De L, I, Hermansen K, et al. Evidence-based nutritional approaches to the treatment and prevention of diabetes mellitus. Nutr Metab Cardiovasc Dis. 2004;14:373–94.

6 Laurenzi A, Bolla AM, Panigoni G, et al. Effects of Carbohydrate Counting on Glucose Control and Quality of Life Over 24 Weeks in Adult Patients With Type 1 Diabetes on Continuous Subcutaneous Insulin Infusion: A randomized, prospective clinical trial (GIOCAR). Diabetes Care. 2011;34:823–7.

7 DAFNE Study group. Training in flexible, intensive insulin management to enable dietary freedom in people with type 1 diabetes: dose adjustment for normal eating (DAFNE) randomised controlled trial. BMJ. 2002;325:746.

8 Bech P, Gudex C, Johansen KS. The WHO (Ten) Well-Being Index: validation in diabetes. Psychother Psychosom. 1996;65:183–90.

9 Trento M, Trinetta A, Borgo E, et al. Carbohydrate counting improves coping ability and metabolic control in patients with Type 1Diabetes managed by Group Care. J Endocrinol Invest. 2010.

10 Buethe M. C-O-U-N-T C-A-R-B-S: a 10-step guide to teaching carbohydrate counting. Diabetes Educ. 2008;34:67–74.

11 Scavone G, Manto A, Pitocco D, et al. Effect of carbohydrate counting and medical nutritional therapy on glycaemic control in Type 1 diabetic subjects: a pilot study. Diabet Med. 2010;27:477–9.

12 Rabasa-Lhoret R, Garon J, Langelier H, Poisson D, Chiasson JL. Effects of meal carbohydrate content on insulin requirements in type 1 diabetic patients treated intensively with the basal-bolus (ultralente-regular) insulin regimen. Diabetes Care. 1999;22:667–73.

13 Sheard NF, Clark NG, Brand-Miller JC, et al. Dietary carbohydrate (amount and type) in the prevention and management of diabetes: a statement by the american diabetes association. Diabetes Care. 2004;27:2266–71.

14 Brown SL, Pope JF, Hunt AE, Tolman NM. Motivational strategies used by dietitians to counsel individuals with diabetes. Diabetes Educ. 1998;24:313–8.

15 Delahanty LM, Halford BN. The role of diet behaviors in achieving improved glycemic control in intensively treated patients in the Diabetes Control and Complications Trial. Diabetes Care. 1993;16:1453–8.

16 Anderson EJ, Richardson M, Castle G, et al. Nutrition interventions for intensive therapy in the Diabetes Control and Complications Trial. The DCCT Research Group. J Am Diet Assoc. 1993;93:768–72.

17 Risk of hypoglycaemia in types 1 and 2 diabetes: effects of treatment modalities and their duration. Diabetologia. 2007;50:1140–7.

18 Kalergis M, Pacaud D, Strychar I, Meltzer S, Jones PJ, Yale JF. Optimizing insulin delivery: assessment of three strategies in intensive diabetes management. Diabetes Obes Metab. 2000;2:299–305.

19 Lowe J, Linjawi S, Mensch M, James K, Attia J. Flexible eating and flexible insulin dosing in patients with diabetes: Results of an intensive self-management course. Diabetes Res Clin Pract. 2008;80:439–43.

20 Samann A, Muhlhauser I, Bender R, Kloos C, Muller UA. Glycaemic control and severe hypoglycaemia following training in flexible, intensive insulin therapy to enable dietary freedom in people with type

1 diabetes: a prospective implementation study. Diabetologia. 2005;48:1965–70.