Effect of quantified table ware use on ABC goals in patients with type 2 diabetes: portions, proportions and perceptions

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Article

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Abstract

Aims: This study examined the effect of 12 months use of quantified tableware (QTW) on glycemic control in patients with type 2 diabetes (T2DM).

Methods: In this prospective, randomized, observational study, 94 adult T2DM patients from the Diabetes Shared Care Network with HbA1c >7% were randomly assigned to control (n=47) and intervention (n=47) groups. All were followed up at the out-patient clinic. The intervention group were given a set of QTW to use. HbA1c, BP and serum LDL cholesterol (LDL), the (ABC) goals were defined as HbA1c <7%, BP <140 mmHg systolic and <90 mmHg diastolic, and LDL <100 mg/dL.

Results: Seventy-seven patients, 43 in the control group and 34 in the intervention group completed the study. After 12 months, fasting glucose (AC) reduced significantly in the control group, while the intervention group had significantly decreased AC, 2-hour postprandial glucose (PC), HbA1c and LDL. Achievement of LDL and 2 ABC goals significantly increased only in the intervention group. All ABC goals were achieved by 21.9% in the intervention group and 12.8% in the control group.

Conclusions: Use of quantified tableware, a low-cost nutritional intervention for 12 months improved AC, PC, HbA1c and LDL cholesterol levels in T2DM patients.

Introduction

The prevalence of diabetes has progressively increased to epidemic proportions worldwide, placing a heavy burden on health care cost. Globally, the estimated prevalence for diabetes in 2015 was 8.8%, affecting 415 million people aged 20–79 years,[1] and was associated with 11.3% of deaths from all causes in 2019.[2]

Type 2 diabetes accounts for about 90–95% of all diabetes[3] and is closely related to several lifestyle and dietary factors.[4] The UK Prospective Diabetes Study showed that improvement in glycemic control reduced diabetes-related related complications in type 2 diabetes patients.[5] However, despite advances in treatment, the majority of diabetes subjects are unable to achieve target goals for HbA1c, blood pressure and lipids at present.[6] Daily optimal blood glucose control is important to prevent diabetes complications.[7] Diet, lifestyle modification and medication are components of diabetes care and medical nutrition therapy improved A1C.[8] Studies showed that Type 2 diabetes patients had misperception for physical activity and vegetable, fruit and fat consumption,[9] and larger portions resulted in greater energy intake.[10] A healthy plate was used for portion control in obese patients.[11] Teaching diabetes subjects to consume appropriate amounts of different groups of food and control portion size could improve glycemic control. We hypothesized whether quantified tableware could be used to improve blood glucose control in type 2 diabetes subjects. The Taiwanese Association of Diabetes Educators (TADE) has developed a set of quantified tableware (QTW) to assist diabetes subjects accurately measure different groups of food. The purpose of this study was to assess the effects of quantified tableware use on achievement of glycemic control in type 2 diabetes (DM) subjects. The primary aim was achievement of HbA1c <7% and the secondary aims were achievement of blood pressure BP <140/90 and LDL-c <100 mg/dl according to the American Diabetes Association guidelines.[12]

Subjects, Materials And Methods

This prospective, randomized study was conducted in Mackay Memory Hospital, a tertiary care medical center in Northern Taiwan from 1st August 2015 to 31st December 2016. A total of 94 type 2 diabetes patients aged 20 years or older were enrolled and randomized into control and intervention groups, with 47 patients in the control group and 47 patients in the intervention group. Inclusion criteria were type 2 diabetes patients aged 20 years or older and A1c >7%, participating in the diabetes shared care network (DSCN) and followed up at the endocrinology outpatient department. Exclusion criteria were

chronic kidney disease (CKD) stage 3 b or over (eGFR ≤30 ml/min), pregnancy, breast feeding, acute liver disease (GPT >120 U/L), malignancy, uncontrolled hypertension (BP ≥160/100), taking oral steroid, recent surgery or acute illness necessitating hospital stay. This study protocol was approved by the institutional review board of Mackay Memorial Hospital (15MMHIS114e). All patients provided written informed consent. All methods of the study were carried out in adherence to relevant guidelines and regulations (Declaration of Helsinki).

In studies conducted on achievement of Hba1c, BP and LDL cholesterol goals, there was fairly common consensus for HbA1c and LDL goals. However, the BP goal varied in different studies, ranging from <130/80 to <140/90. In our study, the ABC goals were defined as HbA1c <7%, BP <140 mmHg systolic and <90 mmHg diastolic, and LDL cholesterol <100 mg/dL, based on guidelines by the American Diabetes Association's Standards of Medical Care in diabetes.[12]

All received scheduled consultations and education once every 3 months during the study period with a registered dietician and registered dietician nurse. Individualized diet education included assessment of current food intake and education on daily calorie requirement and appropriate intake of different groups of food (protein, carbohydrate and fat). Each subject in the intervention group was given a set of quantified tableware to use and received instructions on how to use the tableware (Figure 1). The objective was to accurately measure the different groups of food and liquids consumed at each meal and control calorie intake and portion size. Total daily calorie requirement was calculated by the dietician according to factors such as weight, sex and amount of physical activity. Subjects in the intervention group were taught carbohydrate counting and food exchange to guide appropriate protein, carbohydrate and fat portions.

The quantified tableware consisted of a 4-compartment plate, a calibrated bowl, a mug and a spoon, designed to accurately measure amounts of food and liquids. The plate was divided into 1 large compartment and 3 smaller equal size compartments. The large compartment (230 cc) was for vegetables, without restriction in amount and the 3 small compartments (50 cc each) were for meat or fish. For mixed meals, food was to be placed separately in the relevant compartment representing the major food type. The mug had a capacity of 400 ml for milk (cow's milk, soymilk). The spoon (15 ml) was to measure oil, milk powder and nuts. Participants in the intervention group were asked to document dietary intake and frequency of use of QTW. One set of QTW cost US $:20.67. (Euro:17.45)

A food frequency questionnaire was filled for every subject at baseline, after 3 months, 6 months and 12 months regarding the dietary intake (amount and types) of different food groups within the last month.

Medical history, anthropometry, blood pressure (BP) and biochemistry at recruitment and after one year of follow up were obtained from the medical charts. Drug history included drugs used to treat diabetes, hypertension and hyperlipidemia.

Statistical Analysis

All analyses were performed using the Statistical Package for the Social Sciences (SPSS) software version 21.0 (SPSS Inc., Chicago, IL, USA). Continuous variables of the baseline characteristics of the study participants were expressed as means and SDs. Paired t-test was used to compare the change in metabolic parameters at baseline and after 1 year in the two groups. Dichotomous variables created from achievement of clinical targets like HbA1c <7%, LDL-C <100 mg/dL, BP <140/90 mmHg, any one goal, any two goals and all ABC goals were analyzed by chi-square test. AC, PC and HbA1c trajectories between baseline, 12 weeks, 24 weeks and 48 weeks were assessed by ANCOVA in the control and intervention groups, with baseline values as a covariate and treatment group as fixed effects. A p value <0.05 was considered statistically significant.

Results

A total of 94 type 2 diabetes patients aged 20 years or older were enrolled at baseline. After excluding subjects for loss of follow up, withdrawal from study and incomplete data, 77 adult T2DM patients, 43 in the control group and 34 in the

intervention group, completed the study. The mean age was 58.2 (±11.1) years, and the mean BMI 27.5 kg/m^2.

After 12 months, fasting glucose (AC) (p=0.048) reduced significantly in the control group, while the intervention group had significantly decreased fasting glucose (p=0.012), 2-hour postprandial glucose (PC) (p=0.025), HbA1c (p=0.015) and LDL cholesterol (p=0.008) compared to baseline (Table 1). When both groups were compared, fasting blood glucose was lower in the intervention group. Decreases in AC, PC and HbA1c in the intervention group gained significance during the last six months of QTW use, as shown in Figure 2.

With regard to ABC goals, the HbA1c goal was achieved by 32.4%, BP goal by 79.4% and LDL goal by 55.9% in the intervention group (Table 2). In the control group, 11.6% reached the HbA1c goal, 83.7% the BP goal and 41.86% the LDL goal. Achievement of LDL *(*p=0.003) and 2 ABC goals (p=0.038) significantly increased in the intervention group after 12 months of QTW use when compared to the control group. At baseline, none had all ABC goals in target. After one year, all ABC goals were achieved by 12.8% (5/43) patients in the control group and 20.59% (7/33) patients in the intervention group. When the total group was analyzed, target goals were reached by 20.8% (16/77) for HbA1c, 81.8% (63/77) for BP and 48.1% for LDL (63/77) and 15.6% (12/77) achieved all three ABC goals. There was no significant difference among the two groups concerning the use of drugs for diabetes, hypertension and hyperlipidemia between baseline and after 1 year.

Discussion

This study investigated the effects of quantified table ware as a dietary intervention tool to improve glycemic control in diabetes subjects with poor glycemic control. At baseline all had HbA1c above 7% and none had all three ABC goals within target. Fasting glucose improved in both groups at the end of the study, consistent with evidence that MNT interventions by registered dietitians were effective in decreasing A1c which could be maintained long-term.[8] However, after one year, 2-hour postprandial glucose and HbA1c significantly decreased only in the intervention group and not in the control group. Thus, QTW improved glycemic control in type 2 diabetes patients. Portion size measurement aids were shown to improve estimation accuracy of food consumed.[13] A few controlled clinical trials investigated the use of specially designed plates for portion control in diabetes subjects. Use of a healthy plate reduced body weight in overweight and obese subjects with diabetes [11] and obese type 2 diabetes patients who used a commercially available portion control plate for 6 months had significant weight loss were able to reduce medication for diabetes while maintaining glycemic control.[14] The quantified table ware used in our study differed in including a measuring bowl, calibrated mug and spoon in addition to a plate for the accurate measurement of different groups of food as well as liquids consumed in a meal. Education by the dietician focused on appropriate dietary intake for diabetes patients. Improvement in AC, PC and HbA1c in the intervention group during the last six months of QTW use compared to the first six months could be due to better estimation of food portions with increased frequency of use as time progressed.

The HbA1c target attained by 20.8% in the total group and 32.4% in the intervention group, was the most difficult to achieve in this study. Achievement of HbA1c goal was lower compared to 30.6%-54% in other studies.[15, 16, 17, 18, 19] However, our study differed in that all subjects had poor glycemic control at baseline (HbA1c <7%), unlike other studies which were based on total populations of diabetes patients. Other possible reasons could be influence by factors which could fluctuate such as dietary intake and exercise. In comparison, the LDL goal was most difficult to achieve in the Cascade of diabetes care, where the HbA1c goal was <7-8.5%.[20]

The BP goal was achieved in the majority of the study patients (81.82%), including 86% in the control group and 79.41% in the intervention group, which was higher than in other studies where 64.6%-70% of diabetes subjects reached the BP goal of <140/90.[15,20] BP control is affected by antihypertensive medication among other factors.

Attainment of LDL goal of <100 mg/dl significantly improved in the intervention group (55.9%), similar to other studies where 36.6%-67% reached the LDL goal.[21, 22] Quantified table ware use could have also helped to limit fat intake. After one

year, all ABC goals were achieved by 15.6% (12.8% in the control group and 20.59% in the intervention group. In a study with the same definitions for ABC goals, 9% achieved all ABC goals[23] while 25% achieved all ABC goals in the Cascade of diabetes care study (A1c goal:<7.0%-8.5%).[20] Other studies stressed the importance of multifactorial goal achievement in T2DM subjects. In research conducted on cardiovascular disease risk and ABC goals, the risk of incident cardiovascular disease decreased by 47% with improvement of A1c to <7%, by 27% for LDL control and by 35% for BP control.[24] In the Steno-2 Study, intensified intervention aimed at target goals for HbA1c, lipids and blood pressure reduced the risk of cardiovascular and microvascular events and death rate in at-risk patients with type 2 diabetes.[25, 26] The incidence of cardiovascular disease, stroke and heart failure incrementally reduced when more ABC targets were attained and in those achieving only 1 ABC target, LDL-C reduction was associated with the greatest CVD risk reduction.[27] Benefits of achieving ABCs extend beyond reduction of cardiovascular disease. Type 2 diabetes patients with preserved kidney function who achieved more ABC targets had less decrease in GFR and two or more ABC goal achievement was associated with reduced deterioration of albuminuria.[28]

However, in the real world, despite advances in technology, new drugs for the treatment for diabetes, specialized programs and team care including endocrinologists, dieticians and clinical nurses; the majority of diabetes subjects are still unable to achieve all ABC goals. Some studies have reported improvement in achieving ABC targets in diabetes subjects who had specialized diabetes care or participated in diabetes care programs[17, 22, 19] while others found no significant improvement.[20]

In this study, dietary intervention by the use of quantified table ware of low cost for one year in type 2 diabetes subjects with poor control improved glycemic control with the additional benefit of decrease in LDL. Thus, accurate measurement of food groups and liquids consumed in a meal using quantified tableware could be a tool to assist diabetes patients in improving glycemic control and achieving lipid goals.

Study limitations:

Firstly, our sample from a single diabetes care center was an open-label study and therefore at risk of bias. Secondly, because of our relatively small number of subjects, we can only draw statistically supported conclusions based on our primary endpoint.

Finally, lack of compliance and frequency of use of QTW could have influenced the results as the study period was one year, which is a real-world situation.

Conclusion

Use of quantified tableware as a portion control tool for one year enabled subjects with type 2 diabetes to improve glycemic control and decrease LDL.

Declarations

Acknowledgement:

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Duality of Interest

No potential conflicts of interest relevant to this article were reported.

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Author Contributions

C. H. L. conceived the study, collected and analyzed the data and wrote the paper. M.S.T. conceived the study, interpreted the data and revised the manuscript. C.Y.T and W.R.T. conducted the study and collected and analyzed the data. S.C.L. conducted the study, collected data and revised the manuscript. P.H.H conceived the study, analyzed the data and revised the manuscript. S.M.C. analyzed and interpreted the data and revised the manuscript. C.H.L. and S.M.C. are the guarantors of this work and as such, had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Conflicts of interest

The authors declare that they have no conflicting interests.

Availability of Data and Materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Tables

Table 1. Comparison of achievement of clinical targets at baseline and after one year in control and intervention groups of type 2 diabetes patients.

	Control group (n=43)							Intervention group (n=34)						
	Baseline			After 1 y			p *	Baseline			After 1 y			p *
	mean	±	SD	mean	±	SD		mean	±	SD	mean	±	SD	
Age (years)	59.5	±	10.0	60.5	±	10.0		57.2	±	11.1	58.2	±	11.1	
Male n (%)	16 (36.4%)			16 (36.4%)				20 (43.5%)			20 (43.5%)			
Weight (kg)	70.4	±	13.0	71.0	±	13.3	0.186	69.6	±	13.5	69.8	±	14.0	0.651
BMI (kg/m^2)	27.7	±	4.7	28.0	±	4.5	0.224	27.2	±	4.8	27.3	±	4.70	0.736
SBP (mmHg)	131.8	±	13.3	131.7	±	11.5	0.990	130.8	±	14.4	128.3	±	12.4	0.254
DBP (mmHg)	75.4	±	9.0	75.4	±	8.8	0.981	74.3	±	7.9	73.5	±	8.4	0.579
AC (mg/dL)	179.9	±	50.9	162.9	±	44.6	0.048	171.11	±	58.6	138.5	±	2.0	0.012
PC (mg/dL)	239.1	±	76.1	221.7	±	52.0	0.219	233.3	±	77.5	186.2	±	53.1	0.025
HbA1c (%)	8.6	±	1.3	8.3	±	1.2	0.123	8.3	±	1.1	7.7	±	1.2	0.015
TC (mg/dL)	187.8	±	46.1	196.1	±	48.5	0.195	176.8	±	37.2	176.3	±	33.5	0.935
LDL-C (mg/dL)	108.1	±	29.4	105.9	±	28.3	0.671	112.9	±	34.9	99.0	±	24.2	0.008
HDL-C (mg/dL)	46.0	±	15.0	45.1	±	12.2	0.755	46.3	±	16.4	46.3	±	17.4	0.977
TG (mg/dL)	235.1	±	254.6	214.4	±	166.5	0.581	161.6	±	72.4	168.3	±	78.4	0.560
GPT (mg/dL)	36.7	±	33.4	29.8	±	18.3	0.078	24.7	±	13.4	24.7	±	20.5	0.970
Serum Cr (mg/dL)	0.8	±	0.3	0.9	±	0.3	0.246	0.8	±	0.2	0.8	±	0.2	0.797

Key: n: number, SBP: Systolic Blood Pressure, DBP: Diastolic Blood Pressure, AC: fasting blood glucose, PC: 2-hour post prandial blood glucose, TC: Total cholesterol, LDL-C: Serum low density lipoprotein cholesterol, HDL-C: Serum high density lipoprotein cholesterol, TG: Serum triglycerides and SD: standard deviation. Values are mean with standard deviation. *: difference between baseline and after 12 months within group, paired t test.

Table 2. Comparison of achievement of clinical targets at baseline and after one year in control and intervention groups of type 2 diabetes patients.

Clinical targets	Control group (N=43)			Intervention group (N=34)			between groups*
	Baseline	After 1 y	p	Baseline	After 1 y	p	p
HbA1c <7% (%)	0	5 (11.6%)	-	0	11 (32.4%)	-	0.026
BP <140/90 mmHg (%)	35 (81.4%)	36 (83.7%)	0.612	26 (76.47%)	27 (79.41%)	0.052	0.894
LDL-C <100 mg/dL (%)	20 (46.5%)	18 (41.86%)	0.056	12 (35.3)	19 (55.9%)	0.003	0.407
Any one goal (%)	39 (90.6%)	34 (79.07%)	0.345	30 (88.23%)	30 (88.23%)	0.824	0.335
Any two goals (%)	16 (37.2%)	16 (37.21%)	0.267	8 (23.53%)	18 (52.94%)	0.038	0.252
All ABC goals (%)	0	5 (11.63%)	-	0	7 (20.59%)	-	0.341

Key: n: number, T: total, AC: fasting blood glucose, PC: 2-hour post prandial blood glucose HbA1c: glycated hemoglobin, BP: blood pressure, LDL-C: low-density lipoprotein cholesterol, ABC: A-HbA1c, B-BP, C-LDL-C; NA, not applicable. p: difference between baseline and after 12 months within group, by Chi-Squared Test, *: difference between groups after 1 year

Figures

Figure 1

Quantified tableware consisting of a 4-compartment plate, bowl, calibrated mug, and a spoon.

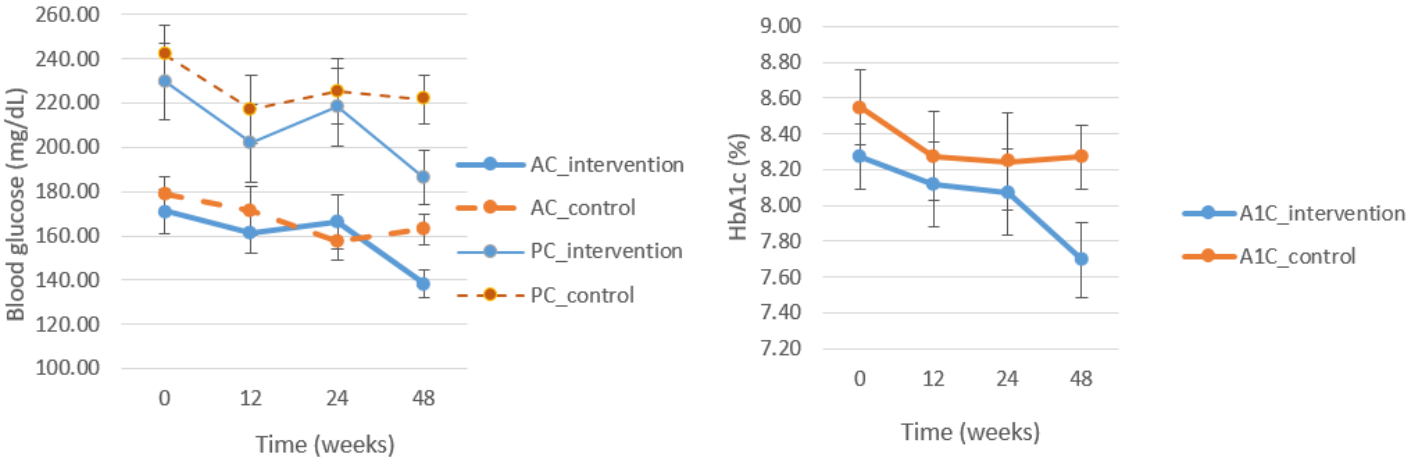

Figure 2

Fasting glucose (AC), postprandial glucose (PC) and glycated hemoglobin (HbA1c) trajectories by ANCOVA in control and intervention groups.

The mean levels of AC and PC (Panel A) and HbA1c (Panel B) in the two groups are shown at different time points during the trial. *p<0.05.