

Article

Not peer-reviewed version

Associations of Total Dietary Quality Score, Dietary Behavior Adherence and Dietary Portion Adherence with Metabolic Factors Among People with Diabetes

[Pi-Hui Hsu](#) , [Ming-Chieh Tsai](#) , Chiao-Ya Chan , [Chih-Yuan Wang](#) , Jung-Fu Chen , [Shih-Te Tu](#) , [Horng-Yih Ou](#) , [Chun-Chuan Lee](#) *

Posted Date: 2 September 2025

doi: 10.20944/preprints202509.0133.v1

Keywords: dietary behaviors adherence; dietary portion adherence; total dietary quality scores



Preprints.org is a free multidisciplinary platform providing preprint service that is dedicated to making early versions of research outputs permanently available and citable. Preprints posted at Preprints.org appear in Web of Science, Crossref, Google Scholar, Scilit, Europe PMC.

Copyright: This open access article is published under a Creative Commons CC BY 4.0 license, which permit the free download, distribution, and reuse, provided that the author and preprint are cited in any reuse.

Disclaimer/Publisher's Note: The statements, opinions, and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions, or products referred to in the content.

Article

Short running title: Total Dietary Quality Score, Dietary Behavior Adherence and Dietary Portion Adherence

Associations of Total Dietary Quality Score, Dietary Behavior Adherence and Dietary Portion Adherence with Metabolic Factors Among People with Diabetes

Pi-Hui Hsu ¹, Ming-Chieh Tsai ^{2,3,4}, Chiao-Ya Chan ³, Chih-Yuan Wang ⁵, Jung-Fu Chen ⁶, Shih-Te Tu ⁷, Horng-Yih Ou ⁸ and Chun-Chuan Lee ^{2,3,*}

- ¹ Dietitian, Ancare nursing home, Taitung, Taiwan
- ² Department of Medicine, Mackay Medical University, New Taipei City, Taiwan
- ³ Division of Endocrinology, Department of Internal Medicine, Mackay Memorial Hospital, Taiwan
- ⁴ Institute of Epidemiology and Preventive Medicine, National Taiwan University, Taipei City, Taiwan
- ⁵ Department of Internal Medicine, National Taiwan University Hospital, College of Medicine, National Taiwan University, Taipei, Taiwan
- ⁶ Division of Endocrinology and Metabolism, Department of Internal Medicine, Kaohsiung Chang Gung Hospital, Chang Gung University College of Medicine, Kaohsiung, Taiwan
- ⁷ Department of Endocrinology and Metabolism, Changhua Christian Hospital, Changhua, Taiwan
- ⁸ Department of Internal Medicine, National Cheng Kung University Hospital, College of Medicine, National Cheng Kung University, Tainan, Taiwan
- * Correspondence: Dr. Chun-Chuan Lee, Division of Endocrinology and Metabolism, Department of Internal Medicine, Mackay Memorial Hospital, No. 92, Zhongshan North Road, Section 2, Taipei City, 104217, Taiwan, Tel: +886-2-2543-3535 extension 2173, Fax: +886-2-2543-2448, Email: r07849036@ntu.edu.tw

Abstract

Aims: To examine whether adherence to dietary behaviors (DBA) and portion recommendations (DPA) after medical nutrition therapy (MNT) is associated with improved metabolic outcomes in individuals with diabetes. **Methods:** This cross-sectional study enrolled 1,002 adults with diabetes from 40 Diabetes Health Promotion Institutions (DHIP) in Taiwan. Registered dietitians assessed DBA and DPA, which were combined into a total dietary quality score (TDQS). Participants were categorized into tertiles: G1 (≤ 106.6), G2 (106.7–119.0), and G3 (≥ 119.1). Associations with metabolic outcomes were analyzed using correlation, ANOVA, logistic, and multiple linear regressions. **Results:** G3 participants had longer diabetes duration, lower BMI, waist circumference (WC), and abdominal obesity. They consumed fewer whole grains and oils, but more vegetables. The proportion achieving ABC targets was significantly higher in G3 than in G2 and G1 (15.9% vs. 14.7% vs. 14.4%), with the most notable difference observed in HbA1c target attainment. Each 1-point increase in the TDQS was associated with reductions in waist circumference (–0.119 cm), BMI (–0.044 kg/m²), HbA1c (–0.012%), and triglyceride levels (–0.883 mg/dL). **Conclusions:** Higher dietary adherence was associated with better metabolic outcomes and ABC goal achievement.

Keywords: dietary behaviors adherence; dietary portion adherence; total dietary quality scores

1. Introduction

The global prevalence of diabetes is steadily increasing. According to the International Diabetes Federation (IDF) Diabetes Atlas 11th Edition, approximately 589 million adults aged 20–79 years are projected to be living with diabetes by 2024, accounting for 11.1% of the global population in this age

(1). In Taiwan, an estimated 2.598 million adults are affected (1). Poor glycemic control is associated with an increased risk of both micro-vascular and macro-vascular complications. To enhance long-term outcomes, Taiwan's government implemented the DHPI program—a multidisciplinary, team-based care model involving physicians, nurses, and dietitians. Patients receive regular consultations and structured diabetes self-management education from certified diabetes educators (CDEs), particularly nurses and dietitians, to strengthen self-care and reduce complications.

MNT plays a pivotal role in diabetes care. The American Diabetes Association (ADA) recommends that individuals with type 1 (T1DM) or type 2 diabetes (T2DM), prediabetes, or gestational diabetes receive individualized MNT from a registered dietitian to achieve treatment goals (2). Despite its importance, adherence to dietary recommendations remains suboptimal, influenced by factors such as limited diabetes-related knowledge, comorbidities, gender, age, education, marital status, and socioeconomic status (3-7).

Unhealthy dietary patterns—such as diets high in saturated fat and cholesterol—are associated with elevated BMI and dyslipidemia. Frequent consumption of sugary foods and snacks is linked to hyperglycemia, and regular eating out is associated with higher blood glucose, lipid levels, blood pressure, and BMI (8). To mitigate cardio-metabolic risk, the ADA advises limiting foods rich in saturated fat (e.g., red meat, full-fat dairy products, butter) and replacing sugar-sweetened beverages (including fruit juices) with water or low/no-calorie alternatives (2). Nutrition education is a core strategy for improving dietary adherence by enhancing patients' knowledge of diabetes-related nutrition. Such interventions have been shown to promote healthier dietary behaviors, including increased intake of fruits, vegetables, low-glycemic index (LGI) foods, dietary fiber, and healthy fats, along with reduced intake of added sugars. These changes are associated with significant improvements in fasting plasma glucose (9). In a study of 2,966 individuals with T2DM, nutrition education was linked to improvements in both dietary behavior and clinical outcomes (10). Patients who actively participated in nutrition education sessions were significantly more likely to adhere to diabetic meal planning (OR = 2.11) and use the food exchange system (OR = 3.07) (11).

To support diabetes prevention and management, individualized meal planning should consider nutrient quality, total caloric intake, and metabolic goals (2). Dietitians provide tailored food portion recommendations; however, adherence to these recommendations—particularly with respect to carbohydrate intake—remains limited (12). In one study of 411 patients with T2DM, those with poor glycemic control consumed significantly more carbohydrates (251 ± 62 gm vs. 213 ± 47 gm) and less dietary fiber (16.7 ± 4.5 gm vs. 20.5 ± 6.1 gm) than those with better glycemic control (13). Other research has shown that nutrition education may improve satiety, reduce hunger, and enhance adherence to dietary recommendations (14). Such interventions are associated with increased compliance with healthy dietary patterns, improved adherence to daily dietary recommendations, and reductions in fasting glucose (9). Moreover, patients with better glycemic control were significantly more likely to meet recommended dietary intake levels (13).

This study aimed to assess the adherence to dietary behaviors and food portion recommendations in individuals with diabetes. It further examined the associations between dietary adherence and metabolic outcomes—including glycemic, blood pressure, blood lipids, and anthropometric measures—and evaluated the potential impact on clinical outcomes.

2. Methods

2.1. Participants

This study was conducted as part of the fourth nationwide Diabetes Quality Survey in Taiwan. Adults (≥ 18 years) with diabetes were recruited from 40 DHPIs using systematic sampling (every fifth patient). This was a cross-sectional study. Eligible participants were T1DM or T2DM who had received care for at least one year and had attended at least one follow-up visit within the past 3 to 6 months. Individuals with duplicate enrollment records or those unwilling or unable to comply with the study were excluded.

All participants provided written informed consent after receiving a detailed explanation of the study. A registered dietitian conducted face-to-face interviews to collect information on dietary intake and behaviors, and to review previous dietary recommendations. Demographic data (e.g., age,

sex, height, weight) and biochemical data from the most recent three months (e.g., HbA1c, LDL-c and triglyceride levels) were collected. This study was conducted between January 1 and December 31, 2018, and was approved by the Joint Institutional Review Board of the Taiwan Medical Research Ethics Foundation (JIRB No. 17-S-019-1).

2.2. Measurement Methods

The DBA score evaluated the frequency of specific dietary behaviors during the preceding week, including intake of high-sugar foods, LGI carbohydrates, and consumption of ≥ 2 servings of whole grains per meal, high-fiber whole grains or tubers, fish rich in n-3 fatty acids (n-3 FAs), high-fat cooked foods, foods high in saturated (SFA) or trans fats (trans-FAs), frequency of dining out, alcohol consumption exceeding two standard drinks per day for men or one for women, and adherence to a balanced intake across the six major food groups. Each behavior was scored individually, with a maximum DBA score of 100 points. The DPA section compared actual intake with recommended portions for six food categories, with each category contributing up to 10 points. For excessive intake, scores were calculated as: $\{10 + (\text{recommended} - \text{actual}) / \text{recommended} \times 10\}$. For insufficient intake, scores were calculated as: $(\text{actual} / \text{recommended}) \times 10$. For vegetables, participants who met or exceeded recommended intake received the full 10 points; lower intakes were scored using the standard formula. The maximum DPA score was 60 points. The sum of DBA and DPA scores yielded the TDQS, ranging from 0 to 160 points.

2.3. Outcome Variables

Ideal body weight (IBW) was calculated as $\text{height (m)}^2 \times 22$. BMI was defined as $\text{weight (kg)} / \text{height (m)}^2$ and categorized as underweight ($<18.5 \text{ kg/m}^2$), normal weight (18.5 to $<24 \text{ kg/m}^2$), overweight (24 to $<27 \text{ kg/m}^2$) and obese ($\geq 27 \text{ kg/m}^2$). Abdominal obesity was defined as a WC $\geq 90 \text{ cm}$ for men and $\geq 80 \text{ cm}$ for women. Targets for optimal metabolic control (ABC) were defined as follows: A: HbA1c $<7\%$, B: blood pressure $<130/80 \text{ mmHg}$, C: LDL-c $<100 \text{ mg/dL}$.

2.4. Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics, version 23. The TDQS were categorized into tertiles: Group 1 (G1: ≤ 106.6 points), Group 2 (G2: 106.7 – 119.0 points), and Group 3 (G3 ≥ 119.1 points). Continuous variables were analyzed using ANOVA with Tukey's post hoc test and are presented as mean $\pm$ standard deviation (SD). Categorical variables were compared using the χ^2 test and are presented as frequencies and percentages (n (%)). Pearson correlation coefficients were calculated to examine associations between DBA scores and anthropometric or biochemical parameters. Logistic regression was used to estimate odds ratios (ORs) and 95% confidence intervals (CIs) for achieving recommended targets for body composition, glycemic, blood pressure, and lipid profiles in G1 and G2, using G3 as the reference. Multiple linear regressions were employed to assess the associations between one-point increases in TDQS, DBA, and DPA scores and changes in BMI, WC, HbA1c, and triglyceride levels. A two-sided $P < 0.05$ was considered statistically significant.

3. Result

A total of 1,131 participants were initially enrolled. After excluding 99 participants with missing DBA data and 30 with missing DPA data, 1,002 participants (454 men and 548 women) were included in the final analysis. The mean age was 61.6 ± 11.9 years, with the average duration of diabetes was 11.0 ± 7.8 years (Table 1). The vast majority (97.9%) had T2DM. Compared with men, women have lower educational attainment (elementary school or below), and exhibit a higher prevalence of abdominal obesity (80.9% vs. 62.3%, $P=0.001$). No significant difference was observed in the achievement of ABC targets between the two sexes. Women also had significantly higher DBA score (70.7 ± 9.2 vs. 68.4 ± 9.5 , $P=0.001$) and TDQS (113.3 ± 14.8 vs. 110.8 ± 15.4 , $P=0.009$). In the dietary behaviors, women demonstrated greater adherence to limiting SFA and trans-FAs intake, reducing dining out frequency, and restricting alcohol consumption. Among individual DBA items, the lowest adherence scores were observed for consumption of LGI carbohydrate foods, fish rich in n-3 FAs, and high-fiber whole grains and tubers.

Among the six food groups, female participants had significantly lower intakes of whole grains (8.8 ± 2.8 vs. 10.7 ± 3.5 servings), protein-rich foods-including soy, fish, eggs, and meat (4.6 ± 1.7 vs. 5.6 ± 2.2 servings), and fats and nuts (5.8 ± 2.5 vs. 6.6 ± 2.9 servings) compared to male participants. Dairy intake was inadequate in both sexes (Table 1). The proportion of dietary protein intake was relatively low in both groups ($14.5 \pm 2.0\%$ vs. $14.8 \pm 1.9\%$ of total calories). Notably, greater consumption of LGI carbohydrate foods was inversely correlated with BMI, WC, and HbA1c (Table 2). Similarly, higher intake of high-fiber whole grains and starchy vegetables was significantly inversely correlated with body weight, BMI, WC, HbA1c, and triglyceride levels.

In table 3, participants were stratified into tertile-based groups according to their TDQS scores: G1 (≤ 106.6), G2 (106.7–119.0), and G3 (≥ 119.1). Participants in G1 were significantly younger and had higher BW, BMI, WC, HbA1c, and smoking rates, as well as lower levels of physical activity compared to those in G2 and G3. The prevalence of obesity and abdominal obesity was lowest among G3 participants (obesity G1:48.8%, G2: 39.8%, G3: 28.4%; abdominal obesity G1:79.5%, G2: 72.0%, G3: 65.7%). Participants in G3 also had a longer duration of diabetes (11.9 ± 8.5 years), lower triglyceride levels (126.9 ± 79.5 mg/dL), and a higher proportion achieving ABC targets (15.9%), with the most pronounced difference observed in HbA1c target attainment (54.1%). In terms of food group intake, G3 participants consumed significantly more vegetables (3.6 ± 1.4 servings/day) and dairy products (0.6 ± 0.6 servings/day) compared to those in G1 and G2. Additionally, G3 had higher energy (25.7 ± 5.7 kcal/kg CBW) and protein intake (0.96 ± 0.25 g/kg CBW). Compared with participants in G3, those in G1 had significantly increased odds of abnormal BW (OR 1.469; 95% CI: 1.018–2.121), abdominal obesity (OR 2.211; 95% CI: 1.492–3.277), elevated HbA1c (OR 1.493; 95% CI: 1.069–2.086), and elevated triglyceride levels (OR 1.547; 95% CI: 1.082–2.212) (Table 4).

As shown in Table 5, each one-point increase in TDQS was associated with significant reductions in WC (-0.119 cm), BMI (-0.044 kg/m²), HbA1c (-0.012%), and triglyceride levels (-0.883 mg/dL). Similarly, each one-point increase in DBA and DPA score was associated with reductions in WC, BMI, HbA1c, and triglyceride levels.

Table 1. Demographic characteristics, anthropometric, biochemical and dietary quality data of participants with diabetes.

Characteristics	All cases (n=1002)		Male (n=454)		Female (n=548)		P value
Age (years)	61.6	± 11.9	61.4	± 11.8	61.8	± 12.0	0.66
DM duration (years)	11.0	± 7.8	11.3	± 8.2	10.7	± 7.4	0.25
Smoke n(%)							
None	756	(75.4)	233	(51.3)	523	(95.4)	0.001
Quit smoking	128	(12.8)	115	(25.3)	13	(2.4)	
Smoking	118	(11.8)	106	(23.3)	12	(2.2)	
Exercise n(%)	334	(66.7)	162	(35.7)	172	(31.4)	0.15
Times of CDE education	6.3	± 2.7	6.4	± 2.7	6.2	± 2.8	0.42
Education n(%)							
Illiterate	37	(3.7)	4	(0.9)	33	(6.0)	0.001
Elementary School	298	(29.7)	99	(21.8)	199	(36.3)	
Junior high school	172	(17.2)	81	(17.8)	91	(16.6)	
High school	242	(24.2)	115	(25.3)	127	(23.2)	
College	246	(24.6)	152	(33.5)	94	(17.2)	
Unknown	7	(0.7)	3	(0.7)	4	(0.7)	
DM type n(%)							
T1DM	20	(2.0)	10	(2.2)	10	(1.8)	0.60
T2DM	981	(97.9)	444	(97.8)	537	(98.0)	
Others	1	(0.1)	0	(0)	1	(0.2)	
Height (cm)	160.6	± 8.4	167.0	± 6.3	155.4	± 6.0	0.001
IBW (kg)	56.9	± 6.0	61.4	± 4.7	53.2	± 4.1	0.001
CBW (kg)	68.4	± 14.0	73.3	± 14.0	64.4	± 12.7	0.001

BMI (kg/m ²)	26.4	± 4.5	26.2	± 4.2	26.6	± 4.8	0.15
Phenotype n (%)							
Underweight	14	(1.4)	5	(1.1)	9	(1.6)	0.52
Normal weight	290	(28.9)	132	(29.1)	158	(28.8)	
Overweight	307	(30.6)	148	(32.6)	159	(29.0)	
Obese	391	(39.0)	169	(37.2)	222	(40.5)	
Waist circumference (cm)	89.5	± 14.8	91.8	± 14.3	87.6	± 14.9	0.001
Abdominal obesity n (%)	715	(72.4)	279	(62.3)	436	(80.9)	0.001
HbA1c (%)	7.4	± 1.4	7.3	± 1.4	7.4	± 1.4	0.63
SBP (mmHg)	132.5	± 17.3	131.8	± 16.7	133.0	± 17.8	0.29
DBP (mmHg)	75.4	± 11.6	75.8	± 10.5	75.0	± 12.4	0.24
Cholesterol (mg/dL)	160.0	± 34.2	154.9	± 33.5	164.1	± 34.3	0.001
Triglyceride (mg/dL)	141.7	± 94.3	142.2	± 104.1	141.3	± 85.6	0.88
HDL (mg/dL)	47.7	± 14.0	44.6	± 12.6	50.1	± 14.5	0.001
LDL (mg/dL)	88.8	± 26.6	87.2	± 26.4	90.0	± 26.8	0.11
Achieving ABC targets n(%)	146	(15.0)	66	(14.9)	80	(15.1)	0.51
A: HbA1c <7% n(%)	495	(49.5)	218	(48.1)	277	(50.5)	0.45
B: Blood pressure <130/80 mmHg n(%)	376	(37.5)	166	(36.6)	210	(38.3)	0.57
C: LDL-c <100 mg/dL n(%)	687	(70.2)	324	(72.8)	363	(68.0)	0.10
DBA items							
Less high sugar food	7.68	± 2.07	7.69	± 1.97	7.68	± 2.16	0.95
CHO food with LGI	4.99	± 2.18	4.92	± 2.12	5.05	± 2.22	0.34
CHO spacing	8.56	± 2.08	8.58	± 2.20	8.55	± 1.98	0.82
High fiber CHO food	5.49	± 2.59	5.39	± 2.62	5.58	± 2.56	0.26
n-3 FAs fish	5.12	± 2.40	5.20	± 2.35	5.05	± 2.45	0.33
Less high oil cooking	7.52	± 2.16	7.47	± 2.18	7.56	± 2.14	0.49
Less high SFA & TFA food	7.22	± 2.14	6.93	± 2.21	7.47	± 2.05	0.001
Less dining out	6.47	± 2.84	5.97	± 2.91	6.88	± 2.72	0.001
Less alcohol drinking	9.38	± 1.65	9.01	± 2.04	9.68	± 1.15	0.001
Balanced diet	7.17	± 2.64	7.29	± 2.60	7.08	± 2.67	0.21
DBA score	69.6	± 9.4	68.4	± 9.5	70.6	± 9.2	0.001
Six major food groups intake							
Whole grains and tubers (S)	9.6	± 3.3	10.7	± 3.5	8.8	± 2.8	0.001
Fruits (S)	1.9	± 1.4	1.8	± 1.4	1.9	± 1.4	0.36
Vegetables (S)`	3.0	± 1.5	3.0	± 1.5	3.1	± 1.5	0.24
Dairy products (S)	0.4	± 0.6	0.4	± 0.6	0.4	± 0.6	0.44
Soy, fish, egg and meat (S)	5.0	± 2.0	5.6	± 2.2	4.6	± 1.7	0.001
Oils and nuts (S)	6.2	± 2.7	6.6	± 2.9	5.8	± 2.5	0.001
Total calorie intake (kcal/day)	1647.8	± 397.9	1783.3	± 405.4	1535.6	± 354.8	0.001
CHO (gm/day)	191.9	± 53.8	206.3	± 56.3	180.0	± 48.7	0.001
CHO (% TC)	46.8	± 7.8	46.5	± 8.1	47.1	± 7.5	0.22
Protein (gm/day)	60.4	± 16.8	66.1	± 17.2	55.7	± 14.9	0.001
Protein (% TC)	14.7	± 2.0	14.8	± 1.9	14.5	± 2.0	0.006
Fat (gm/day)	57.5	± 19.2	62.4	± 20.5	53.4	± 17.0	0.001
Fat (% TC)	31.2	± 6.7	31.3	± 7.0	31.2	± 6.5	0.83
Kcal intake/ kg BW							
Kcal/ kg IBW	29.0	± 6.6	29.1	± 6.6	28.9	± 6.6	0.67
Kcal/ kg CBW	24.7	± 6.5	25.0	± 6.5	24.5	± 6.5	0.30
Protein intake/ kg BW							
gm/kg IBW	1.06	± 0.28	1.08	± 0.28	1.05	± 0.28	0.10
gm/kg CBW	0.91	± 0.28	0.93	± 0.27	0.89	± 0.28	0.05
DPA score	42.5	± 9.6	42.4	± 9.9	42.8	± 9.4	0.54
TDQS	112.2	± 15.1	110.8	± 15.4	113.3	± 14.8	0.009

Abbreviations: IBW, Ideal body weight; CBW, Current body weight; LGL, low glycemic index; TFA, trans fatty acid; S, servings; TC: total calories

Table 2. The correlation between dietary behaviors and anthropometry and biochemical data.

Items	BW	BMI	WC	SBP	DBP	HbA1c	cholesterol	TG	HDL	LDL
Less high sugar food	-0.040	-0.027	0.021	-0.013	-0.078*	-0.057	-0.017	-0.047	0.010	-0.028
CHO food with LGL	-0.061	-0.078*	0.110**	0.043	0.047	0.124**	-0.030	-0.056	0.047	0.021
CHO spacing	-0.018	-0.017	0.023	0.040	0.006	-0.037	-0.015	0.022	-0.089**	0.073*
High fiber CHO food	0.128**	0.134**	0.136**	0.024	-0.018	0.119**	-0.027	-0.072*	0.037	0.006
N-3 FAs fish	-0.030	-0.063*	-0.064*	0.016	-0.013	-0.069*	0.013	-0.020	0.010	-0.010
Less high oil cooking	0.110**	-0.074*	-0.072*	0.009	0.108**	0.083**	-0.024	0.130**	0.060	0.004
Less high SFA & TFA food	0.118**	-0.053	-0.057	0.044	-0.045	-0.062*	-0.100**	0.112**	0.000	-0.048
Less Dining out	0.223**	0.108**	-0.074*	0.016	0.156**	-0.045	-0.032	0.107**	0.065	-0.059
Less alcohol drinking	0.087**	0.024	-0.007	0.043	-0.040	0.028	-0.049	0.116**	-0.003	0.018
Balanced diet	-0.072*	0.116**	0.092**	0.000	0.028	-0.055	-0.079*	0.091**	-0.052	0.011
Total score	0.225**	0.171**	0.149**	0.043	0.095**	0.158**	-0.087**	0.178**	0.024	-0.007

Abbreviations: LGL, low glycemic index; SFA, saturated fatty acid; TFA, trans fatty acid; WC, Waist circumference; TG, triglyceride; HDL, High-density lipoprotein; LDL-c, Low-density lipoprotein. *: P<0.05; **: P<0.005.

Table 3. Comparison of demographic characteristics, anthropometric, biochemical data and diet intake by total diet quality score (TDQS).

		G1≤106.6	G2 106.6-119.0	G3 >119.0	P value
		n = 334	n = 337	n = 331	
Characteristics		Mea n ± SD	Mea n ± SD	Mea n ± SD	
sex	n(%)				
	Male	160 (47.9)	162 (48.1)	132 (39.9)	0.053
age	(years)	58.2 ± 12.6	61.6 ± 12.0	65.2 ± 10	0.001
Smoke	n(%)				
	None	238 (71.3)	246 (73.0)	272 (82.2)	0.001
	Quit smoking	31 (9.3)	56 (16.6)	41 (12.4)	
	Smoking	65 (19.5)	35 (10.4)	18 (5.4)	
Exercise	n(%)	82 (24.6)	105 (31.2)	147 (44.4)	0.001
Times of CDE education		6.3 ± 2.8	6.1 ± 2.8	6.5 ± 2.6	0.26
Education	n(%)				
	Illiterate	11 (3.3)	10 (3.0)	16 (4.8)	0.20

DM type	Elementary school	88	(26.3)	105	(31.2)	105	(31.7)	0.07
	Junior school	72	(21.6)	43	(12.8)	57	(17.2)	
	High school	77	(23.1)	87	(12.8)	78	(23.6)	
	College	84	(25.1)	89	(25.8)	73	(22.1)	
	Unknown	2	(0.6)	3	(26.4)	2	(0.6)	
	T1DM	12	(3.6)	5	(1.5)	3	(0.9)	
DM duration (years)	T2DM	322	(96.4)	332	(98.5)	327	(98.8)	0.01
	others	0	(0)	0	(0)	1	(0.3)	
		10.1	± 7.2 ^a	11.0	± 7.5 ^{a,b}	11.9	± 8.5 ^b	
Height (cm)		161.5	± 8.8 ^a	161.1	± 8.1 ^a	159.3	± 8.1	0.002
CBW (kg)		72.3	± 14.9	68.6	± 13.5	64.4	± 12.4	0.001
BMI (kg/m²)		27.7	± 5.0	26.3	± 4.2	25.3	± 4.0	0.001
Phenotype		n (%)						
Underweight		0	(0)	6	(1.8)	8	(2.4)	0.001
Normal weight		79	(23.7)	94	(27.9)	117	(35.3)	
Overweight		92	(27.5)	103	(30.6)	112	(33.8)	
Obese		163	(48.8)	134	(39.8)	94	(28.4)	
Waist circumference (cm)		92.9	± 14.0	89.1	± 16.1	86.4	± 13.3	0.001
Abdominal obesity		263	(79.5)	237	(72.0)	215	(65.7)	0.001
HbA1c (%)		7.6	± 1.6	7.3	± 1.27 ^a	7.2	± 1.1 ^a	0.001
SBP (mmHg)		131.1	± 18.4	133.4	± 16.1	132.9	± 17.4	0.20
DBP (mmHg)		75.3	± 12.9	76.0	± 11.4	74.9	± 10.5	0.51
Cholesterol (mg/dL)		163.7	± 37.2	157.7	± 33.3	158.5	± 31.8	0.06
Triglyceride (mg/dL)		156.0	± 110.5 ^a	141.7	± 88 ^{a,b}	126.9	± 79.5 ^b	0.001
HDL (mg/dL)		48.1	± 14.4	46.1	± 12.9	48.8	± 14.4	0.05
LDL (mg/dL)		90.1	± 28.8	89.0	± 26.7	87.1	± 24.2	0.34
Achieving ABC targets		47	(14.4)	48	(14.7)	51	(15.9)	0.04
n(%)								
A: HbA1c <7%		143	(42.9)	173	(51.3)	179	(54.1)	0.01
B: Blood pressure <130/80 mmHg		137	(41.0)	120	(35.6)	119	(36.0)	0.27
n(%)								
C: LDL-c <100 mg/dL		222	(67.7)	225	(68.4)	240	(74.5)	0.11
n(%)								
DBA items								
Less high sugar food		7.1	± 2.3	7.8	± 2.0 ^a	8.1	± 1.8 ^a	0.001
Carb food with LGI		4.3	± 2.0	4.9	± 2.0	5.7	± 2.3	0.001
Carb spacing		8.0	± 2.5	8.6	± 2.0	9.1	± 1.5	0.001
High fiber CHO food		4.3	± 2.1	5.6	± 2.5	6.6	± 2.6	0.001
n-3 FAs fish		4.5	± 2.2	5.0	± 2.2	5.8	± 2.6	0.001
Less high oil cooking		6.8	± 2.3	7.6	± 2.1	8.2	± 1.8	0.001
Less high SFA & TFA food		6.6	± 2.3	7.2	± 2.0	7.9	± 2.0	0.001
Less dining out		5.3	± 2.8	6.3	± 2.8	7.7	± 2.3	0.001

Less alcohol drinking		9.0	± 2.2	9.4	± 1.5 ^a	9.7	± 1.0 ^a	0.001
Balanced diet		5.6	± 2.7	7.4	± 2.3	8.5	± 2.0	0.001
DBA score		61.6	± 7.9	69.9	± 6.3	77.4	± 6.3	0.001
DPA score		34.0	± 7.2	42.9	± 6.4	51.0	± 6.1	0.001
Whole grains and tubers	Total servings	10.3	± 4.0	9.5	± 3.0 ^a	9.0	± 2.4 ^a	0.001
	Recom servings	10.2	± 2.1 ^a	10.0	± 2.0 ^a	9.4	± 1.9	0.001
	Score	7.5	± 2.1	8.1	± 1.8	8.8	± 1.5	0.001
Fruits	Total servings	1.7	± 1.7 ^a	2.0	± 1.5 ^b	1.8	± 0.8 ^{ab}	0.006
	Recom servings	2.0	± 0.5	2.0	± 0.5	1.9	± 0.5	0.04
	Score	4.3	± 3.7	5.9	± 3.8	8.0	± 2.8	0.001
Vegetables	Total servings	2.4	± 1.4	3.1	± 1.5	3.6	± 1.4	0.001
	Recom servings	3.8	± 1.0	3.8	± 1.1	3.8	± 1.1	1.00
	Score	6.1	± 2.9	7.6	± 2.4	8.8	± 1.9	0.001
Dairy products	Total servings	0.2	± 0.5	0.4	± 0.6	0.6	± 0.6	0.001
	Recom servings	0.7	± 0.6	0.7	± 0.7	0.6	± 0.6	0.07
	Score	4.2	± 4.8	6.8	± 4.4	8.6	± 3.2	0.001
Soy, fish, egg and meat	Total servings	5.2	± 2.5 ^a	4.9	± 1.9 ^a	4.9	± 1.5	0.04
	Recom servings	5.3	± 1.3	5.4	± 1.4	5.1	± 1.2	0.09
	Score	6.6	± 2.6	7.5	± 2.3	8.4	± 1.9	0.001
Oils and nuts	Total servings	6.6	± 3.3	6.1	± 2.5 ^a	5.9	± 2.1 ^a	0.001
	Recom servings	5.4	± 1.5	5.5	± 1.4	5.6	± 1.5	0.14
	Score	5.2	± 3.2	7.1	± 2.9	8.4	± 2.0	0.001
CHO (gm)		195.4	± 67.4	192.8	± 51.1	187.6	± 39.1	0.17
CHO (% TC)		46.5	± 9.3	47.3	± 7.4	46.7	± 6.3	0.38
Protein (gm)		61.7	± 21.0	59.5	± 15.4	60.1	± 12.8	0.21
Protein (% TC)		14.5	± 2.4 ^{ab}	14.6	± 1.8 ^a	14.9	± 1.6 ^b	0.05
Fat (gm)		60.2	± 23.8	56.4	± 17.9 ^a	55.8	± 14.5 ^a	0.005
Fat (% TC)		31.7	± 7.8	30.9	± 6.6	31.0	± 5.5	0.25
Total calories intake (Kcal)		1694	± 505 ^a	1636	± 371 ^{ab}	1614	± 282 ^b	0.03
Kcal/kg IBW		29.5	± 8.2	28.6	± 6.3	28.9	± 4.8	0.27
Kcal/kg CBW		24.0	± 7.8 ^a	24.4	± 6.1 ^a	25.7	± 5.7	0.002
Protein gm/kg IBW		1.07	± 0.34	1.04	± 0.26	1.08	± 0.23	0.22
Protein gm/kg CBW		0.88	± 0.32 ^a	0.89	± 0.25 ^a	0.96	± 0.25	0.001

^{a, b} Different marker indicate significant differences among the groups. Abbreviations: CBW, current body weight; HDL, high-density lipoprotein; LDL-c: low-density lipoprotein; Recom servings: recommended servings.

Table 4. The effect of TDQS on body weight, waist circumference, HbA1c, LDL and triglyceride levels (Referenced from G3).

outcome	G1 ≤106.6			G2 106.6-119.0		
	OR	95% CI	P	OR	95% CI	P
Abnormal BW	1.765	1.258-2.475	0.001	1.413	1.018-1.962	0.04
model 1	1.598	1.128-2.266	0.008	1.341	0.962-1.870	0.08
model 2	1.469	1.018-2.121	0.04	1.249	0.886-1.762	0.20
Abdominal obesity	2.015	1.418-2.862	0.001	1.342	0.963-1.870	0.08
model 1	2.317	1.592-3.370	0.001	1.492	1.055-2.111	0.02
model 2	2.211	1.492-3.277	0.000	1.380	0.965-1.972	0.08
HbA1c	1.565	1.152-2.125	0.004	1.116	0.824-1.513	0.48
model 1	1.442	1.052-1.978	0.02	1.064	0.782-1.447	0.69
model 2	1.493	1.069-2.086	0.02	1.075	0.779-1.483	0.66
LDL	1.397	0.994-1.966	0.06	1.353	0.961-1.904	0.08
model 1	1.283	0.900-1.828	0.17	1.300	0.919-1.840	0.14

TG	model 2	1.259	0.872-1.816	0.22	1.295	0.908-1.846	0.15
		1.786	1.280-2.492	0.001	1.371	0.978-1.921	0.07
	model 1	1.759	1.247-2.481	0.001	1.365	0.970-1.921	0.07
	model 2	1.547	1.082-2.212	0.02	1.204	0.846-1.714	0.30

model 1: adjusted by gender and age. model 2: adjusted by gender , age, education , DM type, DM duration, smoke, exercise, and times of CDE education. Abnormal BW: include underweight, overweight and obese.

Table 5. Prediction of waist circumference, BMI, HbA1c and triglyceride by TDQS, DBA score and DPA score.

Exposure	metabolic outcome	model 1		model 2	
		B	P value	B	P value
TDQS	WC	-0.169	0.001	-0.137	0.001
	BMI	-0.063	0.001	-0.051	0.001
	A1C	-0.014	0.001	-0.013	0.001
	TG	-1.172	0.001	-1.058	0.001
DBA score	WC	-0.235	0.001	-0.169	0.001
	BMI	-0.083	0.001	-0.059	0.001
	A1C	-0.023	0.001	-0.021	0.001
	TG	-1.802	0.001	-1.607	0.001
DPA score	WC	-0.196	0.001	-0.174	0.001
	BMI	-0.079	0.001	-0.070	0.001
	A1C	-0.013	0.005	-0.011	0.013
	TG	-1.205	0.001	-1.086	0.001

model 1: adjusted sex and age. model 2: adjusted sex, age, education, DM type, DM duration, smoke, exercise, and times of CDE education. Abbreviations: WC, Waist circumference.

4. Discussions

This study represents the first nationwide investigation in Taiwan to examine the association between dietary quality, measured by DBA and DPA, and metabolic outcomes in adults with diabetes. Our findings demonstrate that higher TDQS are significantly associated with lower BMI, WC, HbA1c, and triglyceride levels, highlighting the pivotal role of comprehensive dietary adherence in diabetes management. These results support the incorporation of both behavioral and quantitative dietary assessment tools into MNT strategies.

Participants with higher TDQS not only exhibited more favorable metabolic profiles but also demonstrated greater adherence to health-promoting dietary behaviors, including reduced intake of high-fat and high-sugar foods, improved control of alcohol consumption, and decreased frequency of eating out. These findings are consistent with previous studies indicating that adherence to structured dietary recommendations improves glycemic control and lipid metabolism (2,30,34). Specifically, each one-point increase in TDQS was associated with reductions in HbA1c (−0.012%), triglyceride levels (−0.88 mg/dL), and BMI (−0.044 kg/m²), reflecting dose-dependent improvements observed in structured dietary interventions (14,19,25).

The significant associations observed between individual DBA components and clinical outcomes, particularly for LGI carbohydrates and high-fiber whole grains, further support existing evidence on the metabolic benefits of carbohydrate quality (5,10,23,34). Inverse relationships between high fiber intake and HbA1c, WC, and triglyceride levels reinforce clinical recommendations emphasize whole food-based dietary patterns (16,24,35).

Notably, women in our cohort had significantly higher DBA and TDQS scores than men, yet they also exhibited a higher prevalence of abdominal obesity. This paradox highlights previously reported gender-specific challenges in diabetes care, shaped by hormonal, behavioral, and cultural factors that influence body composition and dietary behaviors (3,7,31). Despite higher dietary behavior scores, women consumed significantly fewer servings of protein-rich foods, whole grains, and dairy products-findings consistent with prior research from both Taiwanese and international populations (8,11,28).

Protein intake was suboptimal in both sexes, with women falling further below recommended thresholds. Inadequate protein consumption among individuals with diabetes has been linked to reduced muscle mass, impaired glucose metabolism, and increased frailty, particularly in older adults (15,25,32,33). These findings underscore the need for targeted education on adequate protein and dairy intake as part of routine diabetes nutrition care, especially for women and elderly populations (13,17,26).

The high prevalence of inadequate food group intake, even among individuals receiving regular education from CDEs under Taiwan’s Diabetes P4P Program, underscores persistent structural and behavioral barriers. Complex dietary recommendations, economic constraints, cultural preferences, and limited food preparation skills may hinder sustained adherence (6,7,18,23). Similar challenges have been documented in low- and middle-income countries such as Ghana, Ethiopia, and Bangladesh, where poor dietary compliance persists despite awareness of guidelines (3-6,13,20,21).

Furthermore, the increasing trend of eating out, particularly among working adults in Taiwan, may compromise food quality and portion control, as previously reported (28). Our finding that higher dining-out frequency is associated with lower DBA scores aligns with previous studies linking frequent eating out to poor dietary quality and elevated cardio-metabolic risk (28,35).

The TDQS used in this study, which integrates behavioral and quantitative dietary measures, may offer superior predictive utility compared to behavior-only indices. Several prior studies have advocated for composite indices that encompass both food types and portion adequacy, given their stronger correlation with clinical outcomes (14,17,29). Our results demonstrate consistent associations between higher TDQS and improved anthropometric and biochemical markers, supporting the use of such comprehensive metrics for patient monitoring and tailored dietary counseling.

Strengths of this study include its large, representative sample of adults with diabetes recruited across 40 certified healthcare institutions, the use of standardized dietary assessment protocols, and the incorporation of both behavioral and portion-based dietary metrics. However, the cross-sectional design limits causal inference, and reliance on self-reported dietary intake may introduce recall and social desirability biases. Nonetheless, dietary interviews conducted by trained dietitians likely enhanced data reliability.

5. Conclusions

In conclusion, our findings support individualized nutrition education that incorporates both behavioral and portion-based components, in alignment with ADA and IDF guidelines (1,2,29). Although Taiwan’s P4P program has standardized access to structured diabetes education, future efforts should prioritize improving protein and dairy intake—particularly among women and older adults (15,25,32,33); and expanding tools to assess and monitor dietary quality in real-world clinical practice (30,34,35). Prospective longitudinal studies are warranted to establish the predictive value of TDQS for long-term diabetes outcomes, including complications, hospitalizations, and quality of life.

Author Contributions: P.-H. H., C.-Y. C., and M.-C. T. designed the study. P.-H. H., and M.-C. T. contributed to writing of the manuscript. P.-H. H., and J.-F. C. contributed software and formal analysis. P.-H. H., S.-T T., H.-Y. O., and C.-C. L. had project administration and data resources. P.-H. H., M.-C. T., C.-Y. C., C.-Y. W., J.-F. C., S.-T T., H.-Y. O., and C.-C. L. had revisions and final approval of the manuscript. C.-C. L. are the guarantor of this work. and P.-H. H., M.-C. T. and C.-Y. W. had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Funding: This study was supported by a grant from the Taiwanese Association of Diabetes Educators (Grant NO: TADE-17-S-019-1).

Institutional Review Board Statement: Informed consent was obtained from all participants, and the study protocol was approved by the Taiwan Joint Institutional Review Board (JIRB No. 17-S-019-1) on December 22, 2017.

Data Availability Statement: Restrictions apply to the availability of some or all data generated or analyzed during this study to preserve patient confidentiality or because they were used under license. The corresponding author will on request detail the restrictions and any conditions under which access to some data may be provided.

Acknowledgments: We gratefully acknowledge the grant support from the Taiwanese Association of Diabetes Educators (Grant No: TADE-17-S-019-1). We also extend our sincere appreciation to all the physicians, nurses, and dietitians who contributed to this project.

Conflicts of Interest: All the other authors have no relationships with any company that might have an interest in the submitted work in the previous 3 years. Their spouses, partners, or children have no financial relationships that may be relevant to the submitted work; and all the authors have no non-financial interests that may be relevant to the submitted work.

References

1. International Diabetes Federation. (2025). *IDF Diabetes Atlas* (11th ed.). Brussels, Belgium: International Diabetes Federation.
2. American Diabetes Association Professional Practice Committee. (2025). Facilitating positive health behaviors and well-being to improve health outcomes: Standards of care in diabetes—2025. *Diabetes Care*, 48(Suppl 1), S68–S80.
3. Aschner, P. (2022). Diabetes trends, epidemiology, and the challenges of prevention. *Colomb Med (Cali)*, 53(1), e1005342.
4. Islam, S. M. S., Niessen, L. W., Ferrari, U., et al. (2017). Effects of knowledge, attitudes, and practices on diabetes and CVD risk factors in Bangladesh: A community-based study. *Global Health Action*, 10(1), 1299138.
5. Bhattarai, M. D., Agrawal, J. P., Rijal, A., et al. (2020). Nutritional factors and dietary pattern associated with glycemic control in T2DM. *Nepal Medical College Journal*, 22(3), 152–158.
6. Ayele, A. A., Melaku, T., & Tadesse, Y. (2022). Adherence to dietary recommendations among diabetic patients in Ethiopia. *BMC Endocrine Disorders*, 22, 54.
7. Lin, Y. N., Hsu, C. C., Hwang, S. J., et al. (2019). Gender differences in the management of type 2 diabetes in Taiwan. *Journal of the Formosan Medical Association*, 118(1 Pt 2), S72–S79.
8. Alqurashi, K. A., Aljabri, K. S., & Bokhari, S. A. (2011). Prevalence of diabetes mellitus in a Saudi community. *Annals of Saudi Medicine*, 31(1), 19–23.
9. Afshin, A., Sur, P. J., Fay, K. A., et al. (2019). Health effects of dietary risks in 195 countries, 1990–2017: A systematic analysis. *The Lancet*, 393(10184), 1958–1972.
10. Evert, A. B., Dennison, M., Gardner, C. D., et al. (2019). Nutrition therapy for adults with diabetes or prediabetes: A consensus report. *Diabetes Care*, 42(5), 731–754.
11. Chen, M. F., Wang, R. H., & Hung, S. L. (2015). Predicting behavioral intention of food safety by using TPB model. *Applied Nursing Research*, 28(4), 282–288.
12. Huang, M. C., Lin, K. D., Cheng, Y. Y., et al. (2015). Nutrition education and dietary adherence among patients with type 2 diabetes. *Diabetes Research and Clinical Practice*, 109(2), 302–309.
13. Chen, W. N., Lee, Y. J., Chiang, C. C., et al. (2020). Association of dietary carbohydrate and fiber intake with glycemic control in type 2 diabetes. *Nutrition Journal*, 19(1), 101.
14. Liu, Y., Hou, S., Leng, J., et al. (2021). Effect of structured nutrition education on glycemic control in patients with T2DM. *Clinical Nutrition*, 40(2), 521–527.
15. Houston, D. K., Nicklas, B. J., Ding, J., et al. (2008). Dietary protein intake is associated with lean mass change in older, community-dwelling adults: The Health ABC Study. *American Journal of Clinical Nutrition*, 87(1), 150–155.
16. Jenkins, D. J. A., Kendall, C. W. C., Augustin, L. S. A., et al. (2012). Effect of legumes as part of a low glycemic index diet on glycemic control and cardiovascular risk factors in type 2 diabetes. *Archives of Internal Medicine*, 172(21), 1653–1660.
17. Franz, M. J., MacLeod, J., Evert, A., et al. (2017). Academy of Nutrition and Dietetics nutrition practice guideline for type 1 and type 2 diabetes in adults: Nutrition intervention evidence reviews and recommendations. *Journal of the Academy of Nutrition and Dietetics*, 117(10), 1659–1679.
18. Hu, E. A., Pan, A., Malik, V., & Sun, Q. (2012). White rice consumption and risk of type 2 diabetes: Meta-analysis and systematic review. *BMJ*, 344, e1454.

19. Miller, C. K., Nagaraja, H. N., & Weinhold, K. R. (2015). Early nutrition education promotes weight loss and glycemic control in adults with newly diagnosed type 2 diabetes. *Diabetes Educator*, 41(5), 623–631.
20. Feleke, B. E. (2020). Dietary practice and associated factors among diabetes patients. *International Journal of Africa Nursing Sciences*, 13, 100252.
21. Kahsay, A. B., Berhe, G., & Alemayehu, M. (2021). Assessment of dietary adherence and associated factors among diabetic patients in Mekelle, Ethiopia. *BMC Nutrition*, 7(1), 9.
22. Riccardi, G., & Rivellese, A. A. (2000). Dietary treatment of the metabolic syndrome—the optimal diet. *British Journal of Nutrition*, 83(Suppl 1), S143–S148.
23. Wang, H. F., Yeh, S. H., & Lin, K. C. (2013). Adherence to a diabetic diet: A study of older Taiwanese patients. *Journal of Clinical Nursing*, 22(17–18), 2351–2359.
24. Schwingshackl, L., & Hoffmann, G. (2015). Diet quality as assessed by the Healthy Eating Index, the Alternate Healthy Eating Index and the Dietary Approaches to Stop Hypertension score and cardiovascular disease. *European Journal of Epidemiology*, 30(7), 609–620.
25. Ghosh, S., Sinha, R. K., & Maity, P. (2021). The role of protein intake in metabolic control in patients with type 2 diabetes: A systematic review and meta-analysis. *Diabetes & Metabolic Syndrome: Clinical Research & Reviews*, 15(5), 102212.
26. Beasley, J. M., Wertheim, B. C., LaCroix, A. Z., et al. (2013). Biomarker-calibrated protein intake and physical function in the Women's Health Initiative. *Journal of the American Geriatrics Society*, 61(11), 1863–1871.
27. Huang, Y. C., Lee, M. S., & Pan, W. H. (2011). Validation of a simplified food frequency questionnaire used in the Nutrition and Health Survey in Taiwan (NAHSIT). *Taiwan Journal of Public Health*, 30(5), 468–480.
28. Lin, Y. H., & Lee, M. S. (2023). The trend and dietary quality of eating-out among Taiwanese adults: A NHIS-based study. *Nutrition, Health & Aging*, 27(1), 54–61.
29. Reedy, J., Lerman, J. L., Krebs-Smith, S. M., et al. (2018). Evaluation of the Healthy Eating Index-2015. *Journal of the Academy of Nutrition and Dietetics*, 118(9), 1622–1633.
30. Oza-Frank, R., Cheng, Y. J., Narayan, K. M., & Gregg, E. W. (2009). Trends in nutrient intake among adults with diabetes in the United States. *Journal of the American Dietetic Association*, 109(7), 1173–1178.
31. Seghieri, G., Policardo, L., Anichini, R., De Bellis, A., & Franconi, F. (2020). Gender differences in the treatment of type 2 diabetes: A real-world study. *Journal of Diabetes Research*, 2020, 7589214.
32. Daly, R. M., O'Connell, S. L., Mundell, N. L., et al. (2014). Protein-enriched diet with resistance training improves functional outcomes in elderly. *Osteoporosis International*, 25(1), 151–159.
33. Deutz, N. E. P., Bauer, J. M., Barazzoni, R., et al. (2014). Protein intake and exercise for optimal muscle function with aging: Recommendations from the ESPEN Expert Group. *Clinical Nutrition*, 33(6), 929–936.
34. Ley, S. H., Hamdy, O., Mohan, V., & Hu, F. B. (2014). Prevention and management of type 2 diabetes: Dietary components and nutritional strategies. *The Lancet*, 383(9933), 1999–2007.
35. Louie, J. C. Y., Dunstan, D. W., Kingwell, B. A., et al. (2011). Glycemic index and glycemic load of carbohydrates in relation to type 2 diabetes. *American Journal of Clinical Nutrition*, 93(2), 365–373.

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.