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Dietary intake in Japanese patients with type 2 diabetes: Analysis from Japan Diabetes Complications Study

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ABSTRACT

Aims/Introduction: Though there are many differences in dietary habits and in the metabolic basis between Western and Asian people, the actual dietary intake in Asian patients with diabetes has not been investigated in a nationwide setting, unlike in Western countries. We aimed to clarify dietary intake among Japanese individuals with type 2 diabetes, and identify differences in dietary intake between Japanese and Western diabetic patients.

Materials and Methods: Nutritional and food intakes were surveyed and analyzed in 1,516 patients with type 2 diabetes aged 40–70 years from outpatient clinics in 59 university and general hospitals using the food frequency questionnaire based on food groups (FFQg).

Results: Mean energy intake for all participants was 1737 ± 412 kcal/day, and mean proportions of total protein, fat, and carbohydrate comprising total energy intake were 15.7, 27.6 and 53.6%, respectively. They consumed a 'low-fat energy-restricted diet' compared with Western diabetic patients, and the proportion of fat consumption was within the suggested range that has been traditionally recommended in Western countries. As a protein source, consumption of fish (100 g) and soybean products (71 g) was larger than that of meat (50 g) and eggs (29 g). These results imply that dietary content and food patterns among Japanese patients with type 2 diabetes are quite close to those reported as suitable for prevention of obesity, type 2 diabetes, cardiovascular disease, and total mortality in Europe and America.

Conclusions: A large difference was shown between dietary intake by Japanese and Western patients. These differences are important to establish ethnic-specific medical nutrition therapy for diabetes.

INTRODUCTION

Medical nutritional therapy is an essential constituent in managing existing diabetes and preventing, or at least slowing, the development of diabetes complications[1]. Thus, it is necessary to determine and assess dietary patterns in diabetes patients. However, there have been no large-scale studies of dietary patterns in nationwide settings from Asian regions except a recent study of elderly diabetic patients[2], although there have been many such studies among populations with diabetes in Western countries, such as the Diabetes Nutrition and Complications Trial, Strong Heart Study, National Health and Nutrition

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Examination Survey, and European Diabetes Centers Study of Complications in Patients with Insulin-Dependent Diabetes Mellitus Complications Study Group[3–6].

Dietary patterns in Asia are quite different from those of Western countries because of differences in food culture, food supply, dietary consumption and nutritional intake. For example, according to a report of the Food and Agriculture Organization (FAO) of the United Nations in 2007[7], the total energy supply and the energy supply from animal products in Asia were lower than those in Western regions (2668 and 402 kcal/day in Asia, 3748 and 1028 kcal/day in the USA, and 3406 and 942 kcal/day in European regions, respectively), although the percentage of energy from vegetable products was higher than in Western regions (85% in Asia, 73% in the USA and 72% in European regions).

In addition, in their joint position statement on the treatment of hyperglycemia, the American Diabetes Association and European Association for the Study of Diabetes encourage the development of individualized treatment plans built around racial and ethnic differences[8]. We reported previously that Japanese type 2 diabetic patients had a much lower body mass index (BMI) than Western patients, even though energy intake was the same, and both groups were similar with regard to age, diabetes duration, hemoglobin A1c (HbA1c) and other clinical variables[9,10]. This suggests a different metabolic basis between East Asians and Western patients with diabetes, such as the degree and influence of insulin deficiency and resistance[11]. Furthermore, it was reported that the profiles of the incidence of complications in diabetic patients differ between Asian and Western countries, such as much lower risks of myocardial infarction, stroke and congestive heart failure in Asian patients compared with Western patients, despite a higher risk of end-stage renal disease in Asian patients[12]. It could be possible that differences in eating patterns influence, at least partly, the differences in profiles of complications between the two groups.

Thus, given the differences in dietary habits and metabolic basis between Western and Asian people, it is necessary to clarify the actual dietary intake among Asian individuals with type 2 diabetes and compare it with that of Western diabetic patients in order to rationally develop effective medical nutritional therapy for diabetes. Our aim of the present study was to elucidate the actual dietary intake among Japanese middle-aged individuals with type 2 diabetes who participated in a nationwide cohort study, and to identify differences between Japanese and Western diabetic patients' dietary intake.

METHODS

Study Population

The Japanese Diabetes Complications Study (JDCS) is a nationwide cohort study of Japanese patients with type 2 diabetes from outpatient clinics in 59 university and general hospitals. Participants were previously diagnosed patients with type 2 diabetes aged 40–70 years whose HbA1c levels were ≥6.5%. Details of the study procedure were published elsewhere[13]. The protocol for the study, which is in accordance with the Declaration of Helsinki and the Ethical Guidelines for Clinical/Epidemiological Studies of the Japanese Ministry of Health Labor and Welfare, received ethical approval from the institutional review boards of all of the participating institutes. Written informed consent was obtained from all patients enrolled. A dietary survey was carried out in the baseline year of 1996. Nutrition and food intakes were assessed by the Food Frequency Questionnaire based on food groups (FFQg). A total of 1,516 of the eligible 2,033 patients completed the FFQg, and their data were analyzed in the present study.

Dietary Assessment

Nutrition and food intakes were assessed by the FFQg. The FFQg is composed of items on 29 food groups and 10 kinds of cookery, and elicits information on the average intake per week of each food or food group in commonly used units or portion sizes. After participants completed the questionnaire, a dietician reviewed the completed questionnaire with the participant. The FFQg was externally validated by comparison with weighed dietary records for seven continuous days of 66 subjects aged 19–60 years[14].

The correlation coefficients between the FFQg and dietary records for energy, protein, fat, carbohydrate, and calcium intakes were 0.47, 0.42, 0.39, 0.49, and 0.41, respectively. Intakes of 26 of the 31 nutrients were not significantly different between the two methods by paired *t*-tests. We used standardized software for population-based surveys and nutrition counseling in Japan (EIYO-KUN v.4.5, manufactured at the site of the Shikoku University Nutrition Database)[15] to calculate nutrient and food intakes, which were based on Japan Dietary Reference Intakes in 1996.

Other Assessments

Other measurements in addition to the dietary survey included a physical examination, blood pressure measurement, neurological/ophthalmological examination, and laboratory tests that included HbA1c, fasting plasma glucose/insulin/C-peptide, serum lipids/creatinine/urea nitrogen and urine analyses[13]. HbA1c assays were standardized by the Lab Test Committee of the Japan Diabetes Society (JDS)[13]. HbA1c values were converted from JDS values into National Glycohemoglobin Standardization Program (NGSP) equivalent values. NGSP equivalent values were calculated using the following formula: NGSP equivalent value (%) = JDS value (%) + 0.4[16]. Physical activity and smoking status were determined by a detailed questionnaire.

Statistical Analysis

All data are presented as means ± standard deviation unless otherwise stated. Differences in the major characteristics between participants who completed and did not complete the FFQg were examined by *t*-tests. All *P*-values are two-sided, and the significance level is 0.05. All statistical analyses were carried out using SAS packages version 9.1 (SAS Institute, Cary, NC, USA).

RESULTS

Table 1 shows the characteristics of the 1,516 type 2 diabetes patients. Their mean BMI was 22.7 kg/m^2, and 23% of the patients had a BMI ≥25 kg/m^2. Their mean age was 59 years, and mean $HbA1_C$ value was 7.9%.

Table 1 | Characteristics of 1,516 diabetic patients who participated in the nutritional and food intake survey of the Japanese Diabetes Complications Study

	Men (*n* = 807)		Women (*n* = 709)		Total (*n* = 1,516)	
	Mean	SD	Mean	SD	Mean	SD
Age (years)	58.4	±7.0	59.0	±6.8	58.7	±6.9
Diabetes duration (years)	11.5	±7.4	10.4	±6.7	11	±7.1
Weight (kg)	62	±8.6	54.2	±8.3	58.4	±9.3
BMI (kg/m^2)	22.7	±2.6	23.2	±3.3	22.9	±3.0
<18.5 kg/m^2	4.0%		6.8%		5.3%	
≥25 kg/m^2	19.3%		28.1%		23.4%	
Waist circumference (cm)	81.9	±7.8	76.6	±9.4	79.4	±9.0
Waist-to-hip ratio	0.89	±0.06	0.83	±0.07	0.86	±0.1
Fasting plasma glucose (mmol/L)	8.9	±2.4	9.0	±2.5	8.9	±2.4
HbA1c (%)	7.7	±1.2	8.1	±1.3	7.9	±1.3
Systolic blood pressure (mmHg)	131	±15.7	131	±16.3	131.4	±16.0
Diastolic blood pressure (mmHg)	77	±9.8	76	±9.9	76.6	±9.9
Total serum cholesterol (mmol/L)	5.0	±0.9	5.4	±0.9	5.2	±0.9
Serum LDL cholesterol (mmol/L)	3.0	±0.9	3.3	±0.8	3.2	±0.8
Serum HDL cholesterol (mmol/L)	1.4	±0.4	1.5	±0.5	1.4	±0.4
Serum triacylglycerol† (mmol/L)	1.2	±0.8	1.1	±0.8	1.1	±0.8
eGFR† (mL/min per 1.73 m^2)	79.4	±33.0	81.8	±36.6	80.3	±33.7
Treated by insulin (%)	18.1%		22.1%		20.0%	
Treated by OHA without insulin (%)	64.7%		67.1%		65.8%	
Current smoker (%)	46.4%		8.7%		28.7%	

eGFR, estimated glomerular filtration rate; HbA1c, hemoglobin A1c; HDL, high-density lipoprotein; LDL, low-density lipoprotein; OHA, oral hypoglycemic agent; SD, standard deviation. †Median and interquartile range.

Table 2 shows the nutritional intake per day and the percentage of participants who met nutritional recommendations[17–19]. The mean daily energy intake for all participants was 1737 ± 412 kcal/day, and the mean proportions of total protein, fat and carbohydrate comprising total energy intake were 15.7, 27.6, and 53.6%, respectively. Saturated fatty acid intake comprised 28.6% of total fat intake. Additionally, we evaluated energy and nutritional intakes, respectively, by patients grouped according to sex, age, intensity of physical activity during work, HbA1C level and diabetes duration. Features of energy intake and nutritional intake, and the percentage of participants who met the nutritional recommendations by Japan and major Western guidelines were similar for each comparison with the exception that the men consumed 180 kcal/day more energy than the women (1820 and 1640 g/day, respectively; Table 2). As for intake of selected food groups per day, the mean total vegetable intake for all participants was 324 g/day (Table 3). As a protein source, consumption of fish (100 g) and soybean products (71 g) was larger than that of meat (50 g) and eggs (29 g). The male patients consumed approximately eightfold more alcoholic beverages than the female patients (115 and 14 g/day, respectively), but the characteristics of food intake did not differ greatly among the patient groups.

Table 4 summarizes the dietary composition of various study populations with diabetes, including the current JDCS participants. The JDCS patients had higher carbohydrate consumption and lower fat consumption than reported among diabetic patients in Western countries (37–50% energy and 35–45% energy, respectively)[3–6]. However, it is necessary to note differences in methods for measurement of dietary intake among the studies. In contrast, the JDCS patients had lower carbohydrate consumption and higher fat consumption than reported for type 2 diabetic patients in Korea[20] and South Africa[21]. The energy intake of JDCS patients was similar to that for Western diabetic patients[3–6], although the Western diabetic patients had a higher BMI than the Japanese diabetic patients.

DISCUSSION

In the present study, we determined the actual dietary intake among Japanese with type 2 diabetes in a nationwide large-scale setting. We clarified that the JDCS patients consumed a 'high-carbohydrate low-fat' diet compared with Western diabetic patients, and that their energy intake was similar to that of Western diabetic patients. In addition, the features of energy intake, and nutritional and food intake among the JDCS patients were similar regardless the differences in sex, age, intensity of physical activity during work, HbA1C level, and diabetes duration.

According to the National Health and Nutrition Survey[22] carried out the same year as the dietary survey of JDCS, energy intake by Japanese men and women aged 40–69 years in the general population ranged from 2214 kcal/day to 2319 kcal/day and

Table 2 | Nutritional intake per day, and percentage of participants who met the nutritional recommendations of the Japan Diabetes Society, Canadian Diabetes Association and American Diabetes Association

	Men (*n* = 807)		Women (*n* = 709)		Age <60 years (*n* = 755)		Age ≥60 years (*n* = 761)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Nutritional intake								
Energy								
kcal	1819	400	1643	405	1760	420	1714	403
Carbohydrate								
% Energy	53.0	6.8	54.2	6.3	52.9	6.7	54.2	6.5
g	239.6	55.4	220.1	48.5	230.9	54.4	230.0	52.0
Protein								
% Energy	15.2	2.3	16.2	2.4	15.6	2.4	15.8	2.4
g	69.7	20.8	67.2	22.7	69.0	22.1	68.0	21.4
Fat								
% Energy	26.7	4.9	28.7	4.8	28.1	5.1	27.2	4.8
g	54.3	17.1	53.2	18.9	55.3	18.5	52.3	17.3
SFAs								
% Energy	7.6	1.7	8.3	1.6	8.0	1.7	7.9	1.6
MUFAs								
% Energy	8.8	2.0	9.3	2.0	9.3	2.1	8.8	2.0
PUFAs								
% Energy	6.4	1.5	6.9	1.5	6.8	1.6	6.5	1.5
n6								
% Energy	5.2	1.3	5.5	1.4	5.5	1.4	5.2	1.3
n3								
% Energy	1.5	0.4	1.6	0.4	1.6	0.4	1.6	0.4
Cholesterol								
mg	316.9	116.9	306.9	118.1	313.1	116.5	311.3	118.6
Ca								
mg	619.6	228.3	661.0	229.5	628.9	228.3	648.9	230.8
Fe								
mg	8.0	2.5	8.2	2.7	8.1	2.6	8.1	2.5
Dietary fiber, total								
g	14.1	5.3	15.4	5.3	14.5	5.4	14.9	5.2
Sodium								
g	4.1	1.5	4.3	1.6	4.1	1.6	4.3	1.5
Recommendation met								
Carbohydrate†								
<55% Energy	61%		55%		61%		55%	
55–60% Energy	24%		29%		25%		27%	
≥60% Energy	15%		17%		13%		18%	
Fat†								
<25% Energy	38%		21%		27%		33%	
SFAs‡								
<7% Energy	35%		17%		26%		27%	
Fiber (total)†								
≥20 g	13%		17%		14%		16%	
Sodium†								
<3.9 g	50%		45%		50%		46%	

Table 2 | (Continued)

	Sedentary occupation (n = 1,032)		Non-sedentary occupation (n = 366)		HbA1c <7% (n = 1,266)		HbA1c ≥7% (n = 250)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Nutritional intake								
Energy								
kcal	1,714	400	1,774	436	1,736	407	1,739	437
Carbohydrate								
% Energy	53.6	6.5	53.9	6.9	53.4	6.7	54.6	6.2
g	227.7	51.1	237.2	59.1	229.5	52.1	235.4	57.9
Protein								
% Energy	15.7	2.4	15.3	2.4	15.7	2.4	15.5	2.2
g	67.9	21.0	68.6	23.1	68.6	21.7	67.9	21.7
Fat								
% Energy	27.7	4.8	27.1	5.3	27.6	5.0	27.8	4.8
g	53.2	17.3	53.9	19.0	53.7	17.9	54.2	18.2
SFAs								
% Energy	8.0	1.6	7.7	1.8	7.9	1.7	8.2	1.7
MUFAs								
% Energy	9.0	2.0	8.8	2.1	9.0	2.1	9.1	2.0
PUFAs								
% Energy	6.6	1.5	6.6	1.6	6.7	1.5	6.5	1.4
n6								
% Energy	5.3	1.3	5.3	1.4	5.4	1.4	5.2	1.2
n3								
% Energy	1.6	0.4	1.5	0.4	1.6	0.4	1.5	0.4
Cholesterol								
mg	311.8	116.2	305.0	118.6	312.2	117.8	312.2	116.2
Ca								
mg	637.4	222.5	631.2	242.4	637.2	232.4	648.0	215.6
Fe								
mg	8.1	2.4	8.1	2.7	8.1	2.6	8.1	2.5
Dietary fiber, total								
g	14.7	5.2	14.4	5.5	14.6	5.3	15.1	5.5
Sodium								
g	4.2	1.5	4.2	1.6	4.2	1.5	4.2	1.6
Recommendation met								
Carbohydrate†								
<55% Energy	58%		57%		59%		52%	
55–60% Energy	26%		26%		26%		28%	
≥60% Energy	16%		17%		15%		20%	
Fat†								
<25% energy	28%		36%		31%		28%	
SFAs‡								
<7% Energy	26%		30%		27%		23%	
Fiber, total†								
≥20 g	16%		12%		15%		17%	
Sodium†								
<3.9 g	49%		50%		48%		48%	

Table 2 | (Continued)

	Diabetes duration <10 years (*n* = 737)		Diabetes duration ≥10 years (*n* = 779)		Total (*n* = 1516)	
	Mean	SD	Mean	SD	Mean	SD
Nutritional intake						
Energy						
kcal	1,762	425	1,708	397	1,737	412
Carbohydrate						
% Energy	53.3	6.5	53.9	6.7	53.6	6.6
g	232.8	55.2	228.0	51.0	230.5	53.2
Protein						
% Energy	15.6	2.4	15.7	2.4	15.7	2.4
g	69.5	22.6	67.3	20.7	68.5	21.7
Fat						
% Energy	27.9	4.9	27.3	5.0	27.6	5.0
g	55.1	18.3	52.4	17.5	53.8	18.0
SFAs						
% Energy	7.9	1.7	7.9	1.7	7.9	1.7
MUFAs						
% Energy	9.1	2.0	8.9	2.0	9.0	2.0
PUFAs						
% Energy	6.7	1.5	6.5	1.5	6.6	1.5
n6						
% Energy	5.4	1.4	5.2	1.3	5.3	1.4
n3						
% Energy	1.6	0.4	1.5	0.4	1.6	0.4
Cholesterol						
mg	316.1	120.2	307.2	114.1	312.2	117.5
Ca						
mg	644.5	238.8	632.3	220.2	639.0	229.7
Fe						
mg	8.3	2.6	7.9	2.5	8.1	2.6
Dietary fiber Total						
g	15.0	5.4	14.4	5.2	14.7	5.3
Sodium						
g	4.3	1.6	4.1	1.5	4.2	1.5
Recommendation met						
Carbohydrate†						
<55% Energy	59%		57%		58%	
55–60% Energy	27%		25%		26%	
≥60% Energy	13%		19%		16%	
Fat†						
<25% Energy	28%		32%		30%	
SFAs‡						
<7% Energy	27%		27%		27%	
Fiber, total†						
≥20 g	17%		13%		15%	
Sodium†						
<3.9 g	48%		49%		48%	

MUFAs, mono-unsaturated fatty acids; n3, n-3 fatty acids; n6, n-6 fatty acids; PUFAs, poly-unsaturated fatty acids; SD, standard deviation; SFAs, saturated fatty acids. †Carbohydrate intake, 50–60% of total energy; fat intake, <25% total energy; fiber, >20 g/day; and sodium, <3.9 g (<10 g as salt) were recommended by the Japan Diabetes Society[17]. ‡Saturated fat intake should be <7% of total energy as recommended by the Canadian Diabetes Association[18] and the American Diabetes Association.[19]

Table 3 | Intake of selected food groups per day

	Men (*n* = 807)		Women (*n* = 709)		Age <60 years (*n* = 755)		Age ≥60 years (*n* = 761)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Grains (g)	207	58	173	40	194	54	189	52
Potato/aroid (g)	50	40	58	50	50	41	57	49
Soybeans/soy products (g)	68	49	75	54	71	51	72	52
Fruits (g)	121	101	148	108	126	107	140	103
Green-yellow vegetables (g)	130	69	147	66	136	67	140	68
Other vegetables (g)	174	103	200	99	184	100	188	104
Meat (g)	52	37	47	39	54	40	46	36
Fish (g)	103	61	97	59	101	61	100	60
Eggs (g)	30	18	28	16	29	16	29	17
Milk/dairy products (g)	165	109	177	94	168	108	173	97
Sweets/snacks (g)	16	20	20	21	18	21	17	20
Oil (g)	17	9	17	9	18	9	16	8
Alcoholic beverages (g)	155	195	14	48	99	180	80	142
Other beverages (g)	44	85	28	67	41	84	33	70

	Sedentary occupation (*n* = 1032)		Non-sedentary occupation (*n* = 366)		HbA1c <7% (*n* = 1266)		HbA1c ≥7% (*n* = 250)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Grains (g)	187	50	202	62	191	53	194	54
Potato/aroid (g)	53	42	55	45	53	42	57	58
Soybeans/soy products (g)	70	49	72	57	72	53	67	44
Fruits` (g)	139	105	118	109	132	104	141	112
Green-yellow vegetables (g)	139	68	132	67	137	67	143	70
Other vegetables (g)	188	102	176	100	184	102	195	103
Meat (g)	49	37	48	39	49	38	52	42
Fish (g)	99	60	100	62	102	61	93	58
Eggs (g)	29	17	28	16	29	17	30	16
Milk/dairy products (g)	170	101	169	107	168	102	184	105
Sweets/snacks (g)	18	20	19	22	17	20	20	23
Oil (g)	17	9	17	9	17	9	17	9
Alcoholic beverages (g)	83	160	103	166	96	169	54	116
Other beverages (g)	35	77	45	83	36	76	41	85

	Diabetes duration <10 years (*n* = 737)		Diabetes duration ≥10 years (*n* = 779)		Total (*n* = 1,516)	
	Mean	SD	Mean	SD	Mean	SD
Grains (g)	191	54	192	53	191	53
Potato/aroid (g)	56	45	51	45	54	45
Soybeans/soy products (g)	73	55	69	48	71	52
Fruits (g)	138	116	129	93	133	105
Green-yellow vegetables (g)	141	67	135	69	138	68
Other vegetables (g)	191	100	181	104	186	102
Meat (g)	51	39	48	37	50	38
Fish (g)	102	62	98	58	100	60
Eggs (g)	29	17	29	16	29	17
Milk/dairy products (g)	169	107	172	98	170	103
Sweets/snacks (g)	19	22	17	19	18	21
Oil (g)	18	9	16	9	17	9

Table 3 (Continued)

	Diabetes duration <10 years (n = 737)		Diabetes duration ≥10 years (n = 779)		Total (n = 1,516)	
	Mean	SD	Mean	SD	Mean	SD
Alcoholic beverages (g)	91	174	86	147	89	162
Other beverages (g)	38	81	35	73	37	77

HbA1c, glycated hemoglobin; SD, standard deviation.

1836 kcal/day to 1916 kcal/day, respectively. Thus, the JDCS patients consumed an energy-restricted diet reduced by 400–500 kcal/day in men and 200–300 kcal/day in women compared with Japanese men and women in the general population.

In addition, the energy intakes by the JDCS patients and Western patients with type 2 diabetes were similar. However, the mean BMI of the JDCS patients was within the normal range, and was much lower than in Western diabetic patients[3–6]. The differences in energy intake between the two groups were too small to explain the large difference in BMI. In terms of the biological aspects of ethnic differences, it is known that Asian people are more susceptible to pancreatic β-cell secretory defects and pronounced dysfunction in early insulin secretion than Western people[23]. In contrast, among Asian populations, the proportion of body fat and prevalence of prominent abdominal obesity are higher than in individuals of European origin with similar BMI values[23]. Also, ethnic differences in biological factors based on genetics, such as the basal metabolic rate, are assumed between Asian and Western people. Further studies are required to clarify the mechanism of the development of type 2 diabetes in consideration of an ethnic-specific constitution, and it should be investigated whether results of dietary assessments and actual food intake differ consistently between Asian and Western patients with diabetes.

The proportions of protein, fat and carbohydrate consumed by JDCS patients met the major current Western guidelines (American Association of Clinical Endocrinologists[24], European Association for the Study of Diabetes[25], Canadian Diabetes Association[18]), which recommend carbohydrate intake ranging from 45 to 65%, fat intake <30–35% and protein intake from 10 to 20%. Furthermore, mean carbohydrate intake as a percentage of energy intake (53.6%) met the current recommendations of the JDS (50–60%)[17], and mean fat intake (27.6%) was 2.6% higher than the recommendation (25% or less)[17]. Therefore, it was clarified that Japanese type 2 diabetic patients consumed a 'low-fat energy-restricted diet', which has been traditionally recommended in Western countries (generally 25–35% of energy from fat)[18,26,27], although the guidelines of the American Diabetes Association for 2011[19] stated the possibility of the effectiveness of both a low-carbohydrate and a low-fat calorie-restricted diet. These proportions of intake by the JDCS patients did not differ much according to sex, age, intensity of physical activity during work, HbA1C level and diabetes duration. In addition, the proportion of fat consumption by the JDCS patients met the definition of low fat intake reported in the recent systematic review by the American Diabetes Association, which might improve glycemic control, total cholesterol and low-density lipoprotein (LDL) cholesterol, but might also lower high-density lipoprotein (HDL) cholesterol[26]. However, the JDCS patients and Western type 2 diabetic patients had similar HDL cholesterol levels (1.4 mmol/L and 1.1–1.2 mmol/L, respectively)[3,4], which is probably a result of the fact that the serum level of HDL cholesterol is naturally higher in East Asians than in Western populations.

The proportions of protein, fat and carbohydrate as percentages of energy supply in the JDCS patients were similar to those reported in elderly Japanese type 2 diabetic patients (fat/carbohydrate: 25.6/59.0%)[2], the general Japanese population (25.8/59.3%)[27], and a comprehensive picture of the pattern of the country's food supply reported in the FAO Balance Sheet (27.3/59.5%)[7]. Furthermore, according to the report of the FAO in 1996[7], fat and carbohydrate as percentages of energy supply in the USA, European region, Spain, Korea, and South Africa were 34.5/53.1%, 33.5/54.4%, 39.5/47.5%, 20.0/68.9%, and 22.0/67.7%, respectively. Thus, the proportions of protein, fat and carbohydrate consumed by diabetic patients in each country were similar to those reported in the FAO Balance Sheet, which reflects dietary patterns for each country[7]. As well as in these countries, it can be estimated that Japanese type 2 diabetes patients' 'low-fat energy-restricted diet' is deeply ingrained in the ethnic-specific dietary pattern of Japan.

As a protein source, consumption of fish and soybean products was larger than that of meat and eggs, and this pattern was similar without regard to sex, age, intensity of physical activity during work, HbA1C level and diabetes duration. These results imply that dietary content and food patterns among Japanese patients with type 2 diabetes were quite close to those in Western countries that have been reported as decreasing the risk of obesity[28], type 2 diabetes[29] and mortality as a result of cardiovascular disease[29], which is known to be higher in Western countries than in Japan. Conversely, the American Diabetes Association noted that soy-derived supplements were not associated with a significant reduction in glycemic measures or risk factors for cardiovascular disease, and that there is limited evidence in relation to protein sources[26].

Table 4 | Summary of literature on dietary composition of diabetic patients including the current Japanese Diabetes Complications Study results

Study name or author	Method for measurement of dietary intake	Years carried out	Study population	Type of diabetes	No. participants (No. men)	Mean age (years)†	Energy intake (kcal)†	Carbohydrate intake (% energy)†	Fat intake (% energy)†	BMI†
Present study (JDCS)	FFQg	1996	Japanese	Type 2 diabetes	1,516 (805)	M: 58.4 W: 59.0	M: 1,819 W: 1,643	M: 53.0 W: 54.2	M: 26.7 W: 28.7	M: 22.7 W: 23.2
EURODIAB IDDM Complications Study Group[6]	3-day record	NA	European	IDDM	2,868 (1458)	33	M: 2,202 W: 1,604	M: 43.1 W: 41.9	M: 37.9 W: 37.9	M: 26 W: 28
	7-day food diaries	1993–1994	Spanish	Type 1 diabetes,	144 (70)	M: 25.0 W: 27.1	M: 2,217 W: 1,623	M: 39.5 W: 40.0	M: 41.5 W: 40.5	M: 22.4 W: 23.2
DNCT[3]				Type 2 diabetes	193 (81)	M: 62.2 W: 62.5	M: 1,788 W: 1453	M: 39.0 W: 38.0	M: 38.5 W: 36.0	M: 25.8 W: 28.5
Strong Heart Study (SHS)[5]	24-h dietary recall	1997–1999	American Indians	Diabetes	1,008 (316)	M: 63.5 W: 63.5	M: 1,595 W: 1,422	M: 48.7 W: 48.7	M: 35.3 W: 35.9	M: 30.6 W: 32.8
NHANES[5]	24-h dietary recall	1999–2000	General US population	Diabetes	373 (190)	M: 64.9 W: 65.3	M: 1,852 W: 1,384	M: 48.4 W: 49.8	M: 34.7 W: 33.8	M: 30.5 W: 32.8
Diabetic Educational Eating Plan study[4]	7-day dietary recall	2005–2006	Clinical trial participants in USA White 85%, Black 5%, Asian 5%, other 5%	Type 2 diabetes	40 (19)	53.5	1,778	36.7	44.6	35.8 <25 5.0% 25–30 17.5% ≥30 77.5%
Lee *et al.*[20]	24-h dietary recall	2003–2004	Korean	Type 2 diabetes	154 (78)	61	M: 1,788 W: 1,546	M: 66.7‡ W: 68.4‡	M: 16.3‡ W: 16.2‡	M: NA W: NA
Kamada *et al.*[2]	FFQg	2001	Japan	Type 2 diabetes	912 (417)	M: 71.4 W: 72.3	M: 1,802 W: 1,661	M: 59.5 W: 58.6	M: 25.4 W: 25.8	M: 23.5 W: 24.0
Nthangeni *et al.*[21]	24-h dietary recall	1998	South African	Type 2 diabetes	290 (133)	<40§	M: 1,971¶ W: 1,712¶	M: 66.7 W: 65.8	M: 13.4 W: 14.4	M: ≥30 15.8% W: ≥30 40.8%

BMI, body mass index; DNCT, Diabetes Nutrition and Complications Trial; EURODIAB IDDM, European Diabetes Centers Study of Complications in Patients with Insulin-Dependent Diabetes Mellitus; IDDM, insulin-dependent diabetes mellitus; JDCS, Japan Diabetes Complications Study; M, men; NA, not available; NHANES, National Health and Nutrition Examination Survey; SHS, Strong Heart Study; W, women. †Maximum value and minimum value are shown if mean value was not available. ‡Estimated from mean value. §Age range was described because mean age was not reported. ¶1 kcal = 4.184 kJ.

Further studies are required to clarify whether glycemic control and risk of cardiovascular disease are affected by soy consumption and other protein sources over a long time period.

Furthermore, 73% of the JDCS patients met the recommendations for saturated fatty acid (SFA) intake (<7% of energy intake[18,19]), and their mean SFA intake was lower than those of Western type 2 diabetes participants (7.9% and 11.2–14.5%, respectively)[3–5].

Just 15% of the JDCS patients ingested 20 g or more of fiber per day, and their mean fiber intake (14.7 g/day) was similar to that of Western type 2 diabetes participants (11.4–20.5 g/day)[3–5] and the general Japanese population (15.7 g/day)[27]. More fiber consumption is recommended for JDCS patients, because it was reported that a high intake of dietary fiber improved fasting plasma glucose and HbA1c values in patients with type 2 diabetes in randomized crossover studies[26]. Increasing fiber intake is recommended to keep diabetes under good control.

The JDCS patients consumed excess sodium, and their mean sodium intake was 4.2 g/day. Thus, their mean sodium intake was lower than in the general Japanese population (4.6 g/day)[27], and higher than in the USA and UK general populations (3.6 and 3.4 g/day, respectively)[30], and a diabetic population in the USA (2.5–3.4 g/day)[5]. High sodium intake directly increases the risk of stroke, and the risk of stroke is decreased by 6% for each 1.15-g/day reduction in sodium intake[31]. Given a 1.15 g/day sodium reduction in JDCS patients, which would result in a sodium intake equal to that in Western diabetes patients, it could be expected that the morality risk of stroke in JDCS patients would be reduced from 7.5 per 1,000 patient-years[32] to 7.0 per 1,000 patient-years.

The present study had several limitations. First, the survey data were collected in 1996, 17 years ago. However, according to results of the National Health and Nutrition Survey[22] in 1996 and 2006, energy intake was slightly decreased (50–100 kcal/day) from 1996 to 2006, and the proportions of fat and carbohydrate did not differ greatly as reported in the FAO Balance Sheet (in 1996: 27.3/59.5%, 2006: 28.7/58.1%, respectively)[7]. Additionally, the characteristics of energy intake and nutritional and food intake by the JDCS patients differed very little between patients <60 years and those aged 60 years or over.

Second, inaccuracies in participants' reported dietary composition on the self-recording questionnaire are possible. Previous data show that being a woman, being obese or desiring to reduce bodyweight are factors related to the likelihood of underreporting energy intake[33]. However, the Japanese type 2 diabetic patients had a much lower BMI compared with Western patients[8]. An additional limitation is that just 74.5% of participants completed the FFQg, and their characteristics were slightly different from those who did not complete the FFQg; therefore, the differences between those who did and did not complete the questionnaire could have potentially influenced the cross-study comparisons of dietary intake. Finally, the method of dietary assessment for type 2 diabetes patients was different in each study that we examined. Establishment of a method that would allow a more direct country-by-country comparison is required.

In conclusion, we clarified that Japanese with type 2 diabetic patients had a 'high-carbohydrate low-fat' diet in comparison with Western diabetic patients, but had an energy intake similar to Western patients with diabetes. Furthermore, the proportions of protein, fat, and carbohydrate consumption and food intake were also quite close to the food pattern that has been traditionally recommended in Western countries.

The present study was a descriptive epidemiological examination to elucidate the actual dietary intake among Japanese middle-aged patients with type 2 diabetes who participated in a nationwide cohort study, and to compare findings with those of Western diabetic patients. Thus, we could not establish a cause–effect model between the risk of diabetes complications and the characteristics of food or nutritional intake, although medical nutritional therapy is an essential constituent for diabetes management.

However, the mean BMI of the JDCS patients was within normal range, whereas the BMI in the Western diabetic patients was higher, even though energy intake in both groups was similar. Additionally, the features of energy intake, and nutritional and food intake also did not differ greatly among the JDCS patients regardless of the differences in sex, age, intensity of physical activity during work, HbA1C level and diabetes duration.

It is possible that the difference in the dietary pattern and ethnic-specific characteristics, such as those related to body fat, prominent abdominal obesity and insulin deficiency and resistance, between Asian and Western people would result in different effects from medical nutritional therapy. Considering ethnic-specific dietary patterns and characteristics is important to explore effective medical nutritional therapy.

Based on preliminary findings, more research is required to survey how food and nutritional intakes among Asian type 2 diabetes patients are associated with the risk of development of diabetic complications, and results should be compared with those in Western patients.

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