Diabetology International (2022) 13:344–357
https://doi.org/10.1007/s13340-022-00575-0

REPORT OF THE COMMITTEE

Dietary intake and physical activity in Japanese patients with type 2 diabetes: the Japan Diabetes Complication and its Prevention prospective study (JDCP study 8)

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Received: 8 December 2021 / Accepted: 23 February 2022 / Published online: 24 March 2022

Abstract
Medical nutrition therapy and exercise therapy are the cornerstones of treatment for patients with type 2 diabetes; however, there has not been a nationwide study on the actual dietary intake and physical activity status of patients since the 2000s. We aimed to clarify this in Japanese patients with type 2 diabetes using data from the Japan Diabetes Complication and its Prevention prospective (JDCP), a nationwide study launched in 2007. A total of 1992 patients with type 2 diabetes, aged 40–75 years, completed either the Brief-type, self-administered Diet History Questionnaire (1643 patients) or International Physical Activity Questionnaire (1834 patients), and their data were analyzed in this study. Mean daily energy intake for all participants was 1686.8 kcal/day, and the mean proportions of carbohydrate, protein, and fat comprising total energy intake were 60.2, 16.2, and 23.6%, respectively. The patients in this study had similar energy and nutrient intake status to patients in the 1996 Japan Diabetes Complications Study; however, Japanese patients still had higher carbohydrate and lower fat consumption than patients with diabetes in Western countries. The physical activity questionnaire reported that 31.0% of patients did not have exercise habits; this was particularly noticeable in female patients and patients under the age of 65. BMI increased from 22.7 to 24.1 kg/m^2 in men and 23.2 to 24.8 kg/m^2 in women from 1996 to 2007, respectively. Further research is required to investigate how dietary intake and physical activity associates with the risk of developing complications in type 2 diabetes patients.

Keywords Type 2 diabetes · Dietary intake · Physical activity · Japan

The members of the JDCP Study Group are listed in Acknowledgements.

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Introduction

Medical nutrition therapy (MNT) and exercise therapy are the cornerstones of treatment for all patients with type 2 diabetes, for controlling diabetes and preventing complications [1]. Previous studies reported that educating patients on the importance of performing and adhering to both MNT and exercise therapy is effective in improving weight control and HbA1c, lipid and blood pressure levels in patients with type 2 diabetes [2, 3]. In a cross-sectional study of outpatients with type 2 diabetes, the prevalence of obesity was high in patients with a combination of high energy intake and low physical activity [4]. Additionally, patients with type 2 diabetes who received lifestyle interventions, including both MNT and exercise therapy, had significantly lower numbers of prescription drugs and hospitalization rates [5]. To help provide more effective treatment for patients with type 2 diabetes, a lot of research into MNT and exercise therapy has been conducted worldwide [1, 6, 7].

In Japan, a nationwide report on dietary intake and physical activity in patients with type 2 diabetes was conducted in 1996, as part of the Japan Diabetes Complications Study (JDCS) [8–10]. A report on type 2 diabetes in elderly Japanese patients was conducted in 2001, as part of the Japanese Elderly Diabetes Intervention Trial (J-EDIT) [11–13]. However, since these studies, there have been no other nationwide surveys on dietary intake and physical activity in Japanese patients with type 2 diabetes.

Several studies on changes in energy and nutrient intake have been conducted in Europe and America. A National Health and Nutrition Examination Survey in the United States reported that energy intake was increased by 206 kcal, salt intake increased by about 339 mg, and fiber intake decreased by 0.9 g between 1988 and 2012 in patients with type 2 diabetes [14]. In addition, a study in Spain reported that protein intake in patients with type 2 diabetes decreased by 6.9% in men and 1.4% in women, and fat intake increased by 3.2% in men and 5.5% in women between 1993 and 2000; although the study size was small at 200 participants [15]. According to the National Health and Nutrition Survey in Japan, Japanese adults have decreased their energy (− 151 g/day) and carbohydrate (− 24.9 g/day) intakes, and increased their protein (12.7 g/day), and salt (3.8 g/day) intakes over the last 20 years [16]. In addition, meat intake was reported to be greater than fish, rice intake was decreased, and the intake of wheat products was increased [16]. MNT is fundamental for self-management, education, and support in the treatment of diabetes [1, 6, 7]; therefore, it is necessary to clarify the actual dietary intake over recent years in order to provide effective dietary guidance and MNT for Japanese patients with type 2 diabetes.

The World Health Organization estimated that insufficient physical activity accounts for about 27% of the causes of diabetes [17], and recommends increasing physical activity [18]. In Western countries, the percentage of patients with type 2 diabetes with regular exercise habits varies from 10 to 80% [19]. A recent nationwide survey in Japan revealed that more than 1/3 of patients with type 2 diabetes perform equal to, or less than, 1 h of 3–5 Mets of leisure, exercise, or movement throughout each day [20]. Further studies are needed to quantitatively assess the amount and intensity of physical activity required in patients with type 2 diabetes to help control their weight. In this study, we investigated the dietary intake status and physical activity status of Japanese patients with type 2 diabetes in a large nationwide study: the Japan Diabetes Complication and its Prevention prospective (JDCP) study, which was launched in 2007.

Patients and methods

Study population

The JDCP study is a nationwide cohort survey of Japanese patients with type 1 or 2 diabetes from outpatient clinics in 464 universities, general hospitals and clinics offering specialist diabetes care. Participants were patients previously diagnosed with type 1 or 2 diabetes, aged ≥ 40 to < 75 years. The study procedure has been published elsewhere [21–25]. The protocol for the study was in accordance with the Declaration of Helsinki and the Ethical Guidelines for Clinical/Epidemiological Studies of the Japanese Ministry of Health Labor and Welfare, and received ethical approval from the institutional review boards of the Japan Diabetes Society Research Ethics Committee and all of the participating institutes. The study was registered with the UMIN Clinical Trial Registry (registry ID, UMIN 000016519).Written informed consent was obtained from all enrolled patients. A total of 7700 patients who met the study inclusion criteria and gave informed consent were enrolled from June 2007 to November 2009. The final number of patients included in this study was 6338, after excluding those who met the criteria as follows: (i) unable to regularly attend their outpatient diabetes clinic; (ii) have proliferative retinopathy; (iii) undergoing dialysis; (iv) diagnosed with malignancy in the last 5 years; and (v) judged to be ineligible for study entry by the study investigators. The dietary survey and physical activity survey were performed at the beginning of the study. Nutrition and food intakes were assessed using the Brief-type, self-administered Diet History Questionnaire (BDHQ) [26, 27]. Physical activity was surveyed using the International Physical Activity Questionnaire (IPAQ) [28, 29]. A total of 1992 patients completed either the BDHQ (1643 patients) or IPAQ (1834 patients), and their data were analyzed in the present study.

Dietary assessment

The BDHQ is a self-administered questionnaire, composed of 58 food and beverage items of each food or food group from selected commonly consumed foods, and is used to estimate dietary intake. General dietary behavior and cooking methods are also surveyed in the BDHQ. Estimates of daily intake of foods and beverages, energy, and nutrients were calculated using an ad hoc computer algorithm for the BDHQ; it incorporates sex-specific portion sizes, determined mainly based on recipe books for Japanese dishes [26]. The nutrient composition of each food item was based on the Standard Tables of Food Composition in Japan [30], edited by the Japanese Ministry of Education, Culture, Sports, Science, and Technology. The details and validity of the BDHQ have been previously reported [26, 27]. The BDHQ was externally validated by comparison with the 16 day weighed dietary records of 92 women and 92 men [26, 27]. The median of Spearman correlation coefficients for food groups was 0.48 in men and 0.44 in women (range 0.22–0.83 and 0.14–0.82 in men and women, respectively) [26] and the median of Pearson correlation coefficients for nutrients was 0.56 in men and 0.54 in women (range 0.19–0.81 and 0.27–0.84 in men and women, respectively) [27].

Physical activity assessment

The short version of the International Physical Activity Questionnaire (IPAQ) assessed the amount and type of physical activity accomplished over the previous 7 day period [28]. It is a self-administered questionnaire and includes questions on how much time was spent performing both vigorous and moderate physical activities, and walking. Questions include all levels of activity, including those accomplished during leisure time, housework, gardening, work- and travel-related activities. A previous report confirmed that the IPAQ was a reliable form of activity measurement ($p = 0.76$) and of a similar standard to other methods of assessment (concurrent = 0.58; criterion = 0.30 against the Computer Science Accelerometer) [28].

The total amount of physical activity performed over 7 days was assessed using the IPAQ data. The number of reported minutes per week in each activity domain was weighted against a metabolic equivalent (MET) energy expenditure estimate. The frequency (days per week) and duration (minutes per day) of either walking, moderate intensity exercise or vigorous intensity exercise was assessed. The total amount of physical activity expended by a participant was determined by weighting each activity by the energy used to complete the exercise, which is defined in METs: 3.3 for walking, 4.0 for moderate exercise and 8.0 for vigorous exercise. A combined score of MET-minutes was determined by multiplying the METs by the number of minutes the activity was performed during one week. Current guidelines for physical activity suggest that regular exercise is the key to good health; therefore, both the total amount and the number of days/sessions were included in the IPAQ analysis calculations. Participants were grouped into three categories, based on their levels of participation in physical activity: (i) high; vigorous intensity activity over a minimum of 3 days, with a minimum of 1500 MET-min/week, or any combination of walking, moderate intensity or vigorous intensity activities, performed over at least 7 days, achieving a minimum of 3000 MET-min/week, (ii) moderate; vigorous intensity activity of at least 20 min per day, performed over 3 days, 5 or more days of moderately intense exercise, and/or walking for a minimum of at least 30 min per day, or 5 or more days of any combination of walking, moderate intensity or vigorous intensity activities, achieving at least 600 MET-min/week, and (iii) low; any participant whose level of physical activity was less than (i) and (ii) [31].

Other assessments

Other assessments included a physical examination, blood pressure, and laboratory tests, including measurements of HbA1c, fasting plasma glucose/postprandial plasma glucose, serum lipids/creatinine/urea nitrogen and urine analyses [21]. History of dyslipidemia, hypertension, stroke, and myocardial infarction, family history of diabetes, alcohol intake, smoking status, status of using oral hypoglycemic agents (OHA), insulin, and antihypertensive agents were also surveyed.

Statistical analysis

Continuous variables were presented as mean ± SD and categorical variables were presented as percentages. For dietary intake and physical activity in type 2 diabetes patients, we presented data using the following subgroups, in addition to overall data: sex, age (< 65 years, ≥ 65 years), HbA1c (< 7.0%, ≥ 7.0%), and duration of diabetes (< 10 years, ≥ 10 years). Continuous variables were examined using the independent-samples *t* test and the χ^2 test was used to compare categorical data. All statistical analyses were performed using SPSS Statistics Version 25 (IBM, Armonk, NY, USA).

Results

The characteristics of the 1992 type 2 diabetes patients in this study are shown in Table 1. The mean BMI was 24.4 ± 3.8 kg/m^2, and 60.2% of the patients were men. The mean age was 61.5 ± 7.8 years, mean duration of diabetes was 10.9 ± 8.0 years, and mean HbA1c value was 7.4 ± 1.2%. The prevalence of participants who were only treated by medical nutrition therapy was 11.6%.

The nutritional intake per day and the percentage of participants who met the nutritional recommendations by the Japan Diabetes Society (JDS) [7] are shown in Table 2. The mean daily energy intake for all participants was 1686.8 ± 554.8 kcal/day, and the mean proportions of carbohydrate, protein, and fat comprising total energy intake were 60.2 ± 7.9, 16.2 ± 3.4, and 23.6 ± 5.7%, respectively. Mean fiber and salt intakes were 13.1 ± 5.5 and 10.8 ± 3.7 g/day, respectively, and the prevalence of patients meeting the recommendations set by the JDS for fiber (≥ 20 g) and salt intakes (men < 7.5 g, women < 6.5 g) [7] were 10.5% and 13.8%, respectively. We also evaluated energy and nutritional intakes according to sex, age, HbA1c level, and diabetes duration in patients. The mean energy and nutrients intake values were similar for each evaluation, except for energy intake between the different genders: men consumed 330 kcal/day more energy than the women (1821.8 ± 574.7 and 1491.2 ± 459.0 g/day, respectively, $p < 0.001$; Table 2). The percentage of patients who met JDS recommendations [7], and percentage of patients who consumed fiber equal to or more than 20 g was low in patients younger than 65 years (age < 65 years: 8.5% and age ≥ 65 years: 13.7%, respectively, $p = 0.001$).

Table 1 Characteristics of patients with type 2 diabetes who participated in the nutritional and food intake survey or physical activity survey for the JDCP Study

	N		All	Men	Women	*p* value
	n	Men (%)	Mean ± SD	Mean ± SD	Mean ± SD	
Age (years)	1992	60.2	61.5 ± 7.8	60.8 ± 8.0	62.5 ± 7.3	< 0.001
Duration of diabetes (years)	1975	60.2	10.9 ± 8.0	11.3 ± 8.3	10.2 ± 7.5	0.003
History (%)	1992	60.2				
Dyslipidemia			49.1%	42.4%	59.2%	< 0.001
Hypertension			48.3%	45.8%	52.0%	0.007
Stroke			2.7%	3.9%	0.8%	0.081
Myocardial infarction			4.8%	5.5%	3.8%	< 0.001
Others			20.1%	19.9%	20.3%	0.822
None			21.6%	25.3%	16.0%	< 0.001
Family history of diabetes (%)	1961	60.2	53.7%	50.8%	58.1%	0.001
Smoker (past/current) (%)	1987	60.1	39.2%	39.9%	38.0%	0.393
BMI (kg/m^2)	1968	60.1	24.4 ± 3.8	24.1 ± 3.2	24.8 ± 4.4	0.001
Waist circumference (cm)	1914	60.5	86.2 ± 10.0	86.5 ± 8.9	85.7 ± 11.4	0.103
HbA1c (%)	1989	60.2	7.4 ± 1.2	7.3 ± 1.3	7.5 ± 1.2	< 0.001
FPG (mg/dL)	976	62.1	134.3 ± 37.2	133.8 ± 36.7	135.2 ± 38.1	0.564
PPPG (mg/dL)	1540	60.3	161.5 ± 59.8	165.9 ± 61.9	154.9 ± 55.7	< 0.001
SBP (mmHg)	1982	60.2	129.5 ± 15.6	128.7 ± 14.5	130.9 ± 16.9	0.003
DBP (mmHg)	1982	60.2	74.5 ± 10.3	74.9 ± 10.0	73.9 ± 10.8	0.042
TC (mg/dL)	1941	60.2	195.1 ± 32.8	191.3 ± 33.0	200.8 ± 31.7	< 0.001
LDL-C (mg/dL)	1910	60.4	112.6 ± 27.3	110.8 ± 26.8	115.3 ± 27.9	< 0.001
HDL-C (mg/dL)	1979	60.5	57.7 ± 16.0	55.0 ± 15.2	61.7 ± 16.3	< 0.001
TG (fasting, mg/dL)	1171	60.4	127.0 ± 85.9	130.4 ± 92.8	121.8 ± 73.8	0.077
non-HDL-C (mg/dL)	1931	60.3	137.4 ± 33.1	136.2 ± 33.7	139.1 ± 32.2	0.066
Serum creatinine (mg/dL)	1974	60.3	0.77 ± 0.33	0.87 ± 0.34	0.63 ± 0.26	< 0.001
eGFR (mL/min/1.73 m^2)	1974	60.3	76.6 ± 19.0	75.4 ± 18.2	78.5 ± 20.1	< 0.001
Serum albumin (mg/dL)	1912	60.3	4.3 ± 0.3	4.3 ± 0.4	4.3 ± 0.3	0.173
Treatment for diabetes (%)	1992	60.2				< 0.001
Medical nutrition therapy only			11.6%	11.4%	11.9%	
OHA			62.2%	65.5%	57.2%	
Insulin only			12.7%	12.0%	13.9%	
Insulin + OHA			13.5%	11.1%	17.0%	

DBP diastolic blood pressure, *eGFR* estimated glomerular filtration rate, *FPG* fasting plasma glucose, *HbA1c* hemoglobin A1c, *HDL* high-density lipoprotein, *LDL* low-density lipoprotein, *OHA* oral hypoglycemic agent, *PPPG* postprandial plasma glucose, *SBP* systolic blood pressure, *SD* standard deviation, *TC* total cholesterol

Table 2 Nutritional intake per day of patients with type 2 diabetes who participated in the JDCP Study

	All ($n=1643$)	Men ($n=972$)	Women ($n=671$)	p value	Age < 65 years ($n=999$)	Age ≥ 65 years ($n=644$)	p value
	Mean ± SD	Mean ± SD	Mean ± SD		Mean ± SD	Mean ± SD	
Nutritional intake							
Energy (kcal)	1686.8 ± 554.8	1821.8 ± 574.7	1491.2 ± 459.0	< 0.001	1692.0 ± 569.1	1678.8 ± 532.0	0.638
Carbohydrate (% energy)[a]	60.2 ± 7.9	61.2 ± 8.1	58.6 ± 7.4	< 0.001	60.4 ± 7.9	59.7 ± 7.8	0.081
Carbohydrate (g)	231.7 ± 77.2	246.1 ± 81.7	210.8 ± 64.7	< 0.001	232.0 ± 79.7	231.1 ± 73.2	0.815
Alcohol (g)	9.3 ± 18.4	14.7 ± 21.7	1.6 ± 6.8	< 0.001	10.4 ± 19.6	7.7 ± 16.4	0.003
Fiber (g)	13.1 ± 5.5	13.1 ± 5.6	13.2 ± 5.3	0.789	12.4 ± 5.1	14.2 ± 5.9	< 0.001
Protein (% energy)	16.2 ± 3.4	15.7 ± 3.4	17.0 ± 3.3	< 0.001	15.8 ± 3.3	16.9 ± 3.5	< 0.001
Protein (g)	68.5 ± 26.8	71.6 ± 27.8	63.9 ± 24.6	< 0.001	66.5 ± 25.9	71.4 ± 27.9	< 0.001
Fat (% energy)	23.6 ± 5.7	23.1 ± 5.8	24.4 ± 5.3	< 0.001	23.8 ± 5.8	23.4 ± 5.5	0.150
Fat (g)	44.6 ± 19.2	47.1 ± 20.3	40.9 ± 16.9	< 0.001	44.9 ± 19.5	44.2 ± 18.8	0.480
Saturated fatty acids (% energy)	6.1 ± 1.7	5.9 ± 1.8	6.3 ± 1.7	< 0.001	6.1 ± 1.8	6.0 ± 1.7	0.146
Saturated fatty acids (g)	11.5 ± 5.5	12.1 ± 5.9	10.6 ± 4.8	< 0.001	11.6 ± 5.6	11.4 ± 5.4	0.412
Monounsaturated fatty acids (g)	15.5 ± 7.2	16.5 ± 7.6	14.0 ± 6.2	< 0.001	15.7 ± 7.3	15.1 ± 6.9	0.072
Polyunsaturated fatty acids (g)	11.3 ± 4.7	12.0 ± 4.9	10.4 ± 4.1	< 0.001	11.3 ± 4.7	11.3 ± 4.6	0.839
n-3 Fatty acids (g)	2.6 ± 1.3	2.7 ± 1.3	2.4 ± 1.2	< 0.001	2.5 ± 1.2	2.7 ± 1.3	0.021
n-6 Fatty acids (g)	8.7 ± 3.6	9.2 ± 3.8	7.9 ± 3.2	< 0.001	8.8 ± 3.7	8.6 ± 3.5	0.267
Vitamin A (μg)	755.1 ± 534.8	775.1 ± 580.8	726.0 ± 459.0	0.056	724.3 ± 489.8	802.7 ± 595.2	0.005
Vitamin D (μg)	16.4 ± 12.1	16.8 ± 12.5	15.7 ± 11.4	0.071	15.1 ± 11.1	18.4 ± 13.3	< 0.001
Vitamin E (mg)	7.0 ± 2.9	7.2 ± 3.0	6.8 ± 2.7	0.018	6.9 ± 2.8	7.2 ± 3.1	0.022
Vitamin K (μg)	352.9 ± 202.0	351.2 ± 209.0	355.3 ± 191.7	0.692	331.5 ± 188.7	386.0 ± 217.1	< 0.001
Vitamin B_1 (mg)	0.75 ± 0.29	0.77 ± 0.30	0.73 ± 0.27	0.005	0.73 ± 0.27	0.79 ± 0.31	< 0.001
Vitamin B_2 (mg)	1.33 ± 0.50	1.37 ± 0.53	1.26 ± 0.45	< 0.001	1.28 ± 0.47	1.40 ± 0.53	< 0.001
Niacin (mg)	17.3 ± 7.4	18.2 ± 7.7	15.8 ± 6.6	< 0.001	17.1 ± 7.2	17.5 ± 7.6	0.290
Vitamin B6 (mg)	1.30 ± 0.53	1.34 ± 0.55	1.23 ± 0.48	< 0.001	1.25 ± 0.50	1.36 ± 0.56	< 0.001
Vitamin B12 (μg)	10.5 ± 7.0	11.1 ± 7.3	9.7 ± 6.6	< 0.001	10.1 ± 6.8	11.2 ± 7.3	0.001
Folate (μg)	387.8 ± 162.9	389.6 ± 169.6	385.2 ± 152.8	0.583	369.9 ± 151.5	415.7 ± 175.7	< 0.001
Pantothenic acid (mg)	6.3 ± 2.4	6.6 ± 2.5	6.0 ± 2.1	< 0.001	6.1 ± 2.2	6.7 ± 2.5	< 0.001
Vitamin C (mg)	131.9 ± 64.3	127.9 ± 65.1	137.7 ± 62.8	0.002	123.9 ± 58.9	144.4 ± 70.3	< 0.001
Na (mg)	4281.3 ± 1472.5	4558.1 ± 1496.0	3880.4 ± 1341.0	< 0.001	4189.4 ± 1402.0	4424.0 ± 1566.1	0.002
Salt equivalent (g)	10.8 ± 3.7	11.5 ± 3.8	9.8 ± 3.4	< 0.001	10.6 ± 3.5	11.2 ± 4.0	0.002
K (mg)	2681.4 ± 1037.1	2729.7 ± 1077.1	2611.4 ± 972.7	0.023	2570.2 ± 961.5	2853.8 ± 1123.7	< 0.001
Ca (mg)	570.9 ± 255.0	582.0 ± 264.7	554.8 ± 239.5	0.034	534.3 ± 230.9	627.7 ± 279.3	< 0.001
Mg (mg)	266.8 ± 95.8	276.9 ± 98.9	252.3 ± 89.2	< 0.001	257.6 ± 90.1	281.1 ± 102.4	< 0.001
P (mg)	1056.0 ± 412.1	1101.1 ± 424.5	990.6 ± 384.5	< 0.001	1017.9 ± 387.6	1115.0 ± 441.3	< 0.001
Fe (mg)	8.2 ± 3.1	8.4 ± 3.2	7.9 ± 2.9	0.003	7.9 ± 2.9	8.7 ± 3.3	< 0.001
Zn (mg)	7.8 ± 2.8	8.2 ± 2.9	7.3 ± 2.5	< 0.001	7.7 ± 2.7	8.1 ± 2.9	0.008
Cu (mg)	1.18 ± 0.39	1.22 ± 0.41	1.12 ± 0.36	< 0.001	1.15 ± 0.38	1.23 ± 0.41	< 0.001
Mn (mg)	3.62 ± 1.21	3.74 ± 1.27	3.45 ± 1.09	< 0.001	3.55 ± 1.18	3.73 ± 1.24	0.003
Recommendation met[b]							
Fiber							
≥ 20 g	10.5%	10.5%	10.6%	0.955	8.5%	13.7%	0.001
Sodium							

Table 2 (continued)

	All ($n = 1643$)	Men ($n = 972$)	Women ($n = 671$)	p value	Age < 65 years ($n = 999$)	Age ≥ 65 years ($n = 644$)	p value
	Mean ± SD	Mean ± SD	Mean ± SD		Mean ± SD	Mean ± SD	
Men < 7.5 g, women < 6.5 g	13.8%	13.4%	14.5%	0.532	14.5%	12.7%	0.307

	Duration of diabetes < 10 years ($n = 818$)	Duration of diabetes ≥ 10 years ($n = 808$)	p value	HbA1c < 7% ($n = 710$)	HbA1c ≥ 7% ($n = 931$)	p value
	Mean ± SD	Mean ± SD		Mean ± SD	Mean ± SD	
Nutritional intake						
Energy (kcal)	1711.5 ± 578.0	1663.0 ± 532.9	0.079	1726.7 ± 520.9	1656.1 ± 578.0	0.011
Carbohydrate (% energy)[a]	60.3 ± 7.9	60.0 ± 7.9	0.493	60.0 ± 8.1	60.3 ± 7.7	0.457
Carbohydrate (g)	236.3 ± 80.8	227.4 ± 73.7	0.021	233.6 ± 71.0	230.2 ± 81.6	0.374
Alcohol (g)	9.0 ± 18.2	9.4 ± 17.9	0.726	11.0 ± 19.8	8.1 ± 17.3	0.002
Fiber (g)	13.2 ± 5.4	13.1 ± 5.5	0.747	13.7 ± 5.4	12.7 ± 5.5	< 0.001
Protein (% energy)	16.1 ± 3.4	16.4 ± 3.4	0.086	16.4 ± 3.5	16.1 ± 3.3	0.081
Protein (g)	69.0 ± 27.7	68.1 ± 26.0	0.509	71.1 ± 27.7	66.4 ± 25.9	0.001
Fat (% energy)	23.6 ± 5.6	23.6 ± 5.7	0.936	23.6 ± 5.8	23.6 ± 5.6	0.991
Fat (g)	45.2 ± 19.5	44.0 ± 19.0	0.217	45.7 ± 19.2	43.7 ± 19.2	0.036
Saturated fatty acids (% energy)	6.0 ± 1.7	6.1 ± 1.8	0.615	6.0 ± 1.7	6.1 ± 1.8	0.243
Saturated fatty acids (g)	11.6 ± 5.6	11.4 ± 5.5	0.345	11.7 ± 5.4	11.4 ± 5.6	0.249
Monounsaturated fatty acids (g)	15.7 ± 7.3	15.2 ± 7.1	0.134	15.8 ± 7.2	15.2 ± 7.1	0.066
Polyunsaturated fatty acids (g)	11.5 ± 4.7	11.2 ± 4.6	0.205	11.7 ± 4.8	11.0 ± 4.6	0.002
n-3 Fatty acids (g)	2.6 ± 1.3	2.6 ± 1.3	0.512	2.7 ± 1.3	2.5 ± 1.2	0.001
n-6 Fatty acids (g)	8.8 ± 3.7	8.6 ± 3.6	0.161	9.0 ± 3.7	8.5 ± 3.6	0.004
Vitamin A (μg)	758.9 ± 562.0	753.2 ± 509.5	0.830	786.8 ± 559.2	730.8 ± 515.0	0.036
Vitamin D (μg)	16.2 ± 12.1	16.7 ± 12.1	0.489	17.2 ± 12.9	15.7 ± 11.3	0.018
Vitamin E (mg)	7.1 ± 3.0	6.9 ± 2.9	0.164	7.3 ± 3.0	6.8 ± 2.9	0.002
Vitamin K (μg)	350.7 ± 196.0	356.1 ± 208.4	0.593	378.6 ± 210.3	332.8 ± 193.3	< 0.001
Vitamin B_1 (mg)	0.77 ± 0.29	0.73 ± 0.28	0.001	0.76 ± 0.29	0.74 ± 0.28	0.001
Vitamin B_2 (mg)	1.37 ± 0.50	1.29 ± 0.49	0.001	1.32 ± 0.51	1.33 ± 0.49	0.001
Niacin (mg)	17.9 ± 7.6	16.8 ± 7.2	0.002	17.4 ± 7.5	17.1 ± 7.3	0.002
Vitamin B6 (mg)	1.35 ± 0.53	1.25 ± 0.52	< 0.001	1.31 ± 0.54	1.29 ± 0.52	< 0.001
Vitamin B12 (μg)	10.7 ± 7.4	10.5 ± 6.7	0.498	11.1 ± 7.5	10.1 ± 6.6	0.004
Folate (μg)	387.9 ± 164.6	388.3 ± 162.1	0.956	402.7 ± 163.8	376.3 ± 161.5	0.001
Pantothenic acid (mg)	6.4 ± 2.4	6.3 ± 2.3	0.689	6.6 ± 2.4	6.2 ± 2.3	< 0.001
Vitamin C (mg)	132.8 ± 64.9	131.2 ± 63.9	0.607	134.9 ± 63.4	129.6 ± 65.0	0.103
Na (mg)	4295.0 ± 1474.0	4279.8 ± 1478.0	0.835	4403.6 ± 1509.4	4185.5 ± 1434.5	0.003
Salt equivalent (g)	10.8 ± 3.7	10.8 ± 3.7	0.833	11.1 ± 3.8	10.6 ± 3.6	0.003
K (mg)	2692.7 ± 1044.3	2675.4 ± 1035.3	0.737	2781.5 ± 1037.1	2604.6 ± 1032.0	0.001
Ca (mg)	567.3 ± 260.2	576.3 ± 250.9	0.478	595.0 ± 264.7	552.2 ± 245.9	0.001
Mg (mg)	267.4 ± 97.1	266.7 ± 95.0	0.888	277.9 ± 96.1	258.3 ± 94.7	< 0.001
P (mg)	1060.1 ± 423.9	1054.5 ± 402.0	0.785	1097.2 ± 426.5	1024.1 ± 397.6	< 0.001
Fe (mg)	8.2 ± 3.2	8.2 ± 3.0	0.772	8.5 ± 3.1	7.9 ± 3.0	< 0.001
Zn (mg)	7.9 ± 2.9	7.7 ± 2.7	0.151	8.1 ± 2.9	7.6 ± 2.7	< 0.001
Cu (mg)	1.22 ± 0.38	1.15 ± 0.40	< 0.001	1.20 ± 0.41	1.17 ± 0.38	< 0.001
Mn (mg)	3.68 ± 1.16	3.58 ± 1.24	0.108	3.64 ± 1.21	3.61 ± 1.21	0.108
Recommendation met[b]						
Fiber						

Table 2 (continued)

	Duration of diabetes < 10 years ($n = 818$) Mean ± SD	Duration of diabetes ≥ 10 years ($n = 808$) Mean ± SD	p value	HbA1c < 7% ($n = 710$) Mean ± SD	HbA1c ≥ 7% ($n = 931$) Mean ± SD	p value
≥ 20 g	11.0%	10.3%	0.633	11.7%	9.7%	0.186
Sodium						
Men < 7.5 g, women < 6.5 g	12.0%	15.3%	0.048	12.4%	14.9%	0.140

SFA saturated fatty acids, *MUFA* monounsaturated fatty acids, *% E* % Energy, *PUFA* polyunsaturated fatty acids

[a]Mean proportions of carbohydrate comprising total energy intake was calculated as follows: 100 (%E) − protein (%E) − fat (%E)

[b]Recommended by the Japan Diabetes Society [7]

Selected food group intake per day is shown in Table 3. The mean intake of green-yellow vegetables and other vegetables for all participants was 125.1 ± 81.8 and 165.8 ± 98.4 g/day, respectively. For the protein source, the consumption of fish (93.5 g/day) and soybean products (68.2 g/day) were greater than the consumption of meat (54.1 g/day) and eggs (33.3 g/day). Male patients consumed approximately eightfold more alcoholic beverages than female patients (162.1 ± 262.5 and 20.3 ± 85.8 g/day, respectively, $p < 0.001$), and patients younger than 65 years consumed approximately 1.6-fold more alcoholic beverages than patients who were equal to or older than 65 years (122.1 ± 247.8 and 76.3 ± 166.1 g/day, respectively, $p < 0.001$). The mean total vegetable intake was low in patients younger than 65 years (276.3 g/day) compared with patients equal to or older than 65 years (313.4 g/day, $p < 0.001$); however, the characteristics of food intake did not differ greatly among the patient groups.

The physical activity characteristics of patients with type 2 diabetes are shown in Table 4. The mean weekly physical activity for all participants was 2186.8 ± 2523.6 METs min/week, and the prevalence of physical activity regarded as high, moderate, or low level was 23.8%, 45.3%, and 31.0%, respectively. The prevalence of all patients achieving: (i) vigorous intensity activity on at least 3 days, with a minimum total physical activity of at least 1500 MET-min/week, was 11.9%; (ii) 7 or more days of any combination of walking, moderate intensity or vigorous intensity activities: a minimum total physical activity of at least 3000 MET-min/week, was 21.4%; (iii) 3 or more days of vigorous intensity activity of at least 20 min per day, was 12.2%; (iv) 5 or more days of moderate intensity activity and/or walking of at least 30 min per day, was 63.8%; and (v) 5 or more days of any combination of walking, moderate intensity or vigorous intensity activities, with a minimum total physical activity of at least 600 MET-min/week, was 66.5%. The weekly physical activity in female patients was lower than in male patients (1948.3 ± 2209.3 and 2344.5 ± 2700.9 METs min/week, respectively, $p < 0.001$). The weekly physical activity in patients younger than 65 year was lower than in patients equal to or older than 65 year (2067.8 ± 2427.6 and 2366.8 ± 2653.7 METs min/week, respectively, $p = 0.013$). The percentage of female patients with low physical activity was higher than for male patients (34.3% and 28.8%, respectively) and patients younger than 65 years had a higher rate of low physical activity compared with patients who were equal to or older than 65 years old (33.7% and 26.8%, respectively).

Discussion

In the present study, we determined the actual dietary intake and physical activity status among Japanese patients with type 2 diabetes as part of the JDCP study, a nationwide large-scale survey launched in 2007. The overall, mean daily energy intake for JDCP participants was 1686.8 kcal/day, and the mean proportions of carbohydrate, protein, and fat comprising the total energy intake were 60.2, 16.2, and 23.6%, respectively. Mean fiber and salt intakes were 13.1 and 10.8 g/day, respectively. In 1996, the JDCS reported that the mean daily energy intake for Japanese patients with type 2 diabetes was 1737 kcal/day, the mean proportions of carbohydrate, protein, and fat comprising total energy intake were 56.7, 15.7, and 27.6%, respectively, and mean fiber and salt intakes were 14.7 and 10.7 g/day, respectively. The results are similar between the two studies, although the fat intake ratio and fiber intake was slightly lower in the JDCP study compared to the JDCS. It is important to note there were differences in measurement methods between the studies; however, the results indicate that the dietary intake of Japanese patients with type 2 diabetes remains substantially unchanged. Compared with diabetic patients in Western countries, the carbohydrate consumption was still higher and the fat consumption lower in Japanese patients with type 2 diabetes: 37–50%, and 35–45%, respectively, in Western countries [8]. The trends in dietary intake status

Table 3 Nutritional intake per day of patients with type 2 diabetes who participated in the JDCP Study

	All ($n=1643$)	Men ($n=972$)	Women ($n=671$)	p value	Age < 65 years ($n=999$)	Age ≥ 65 years ($n=644$)	p value
	Mean ± SD	Mean ± SD	Mean ± SD		Mean ± SD	Mean ± SD	
Grains (g)	401.4 ± 161.5	436.2 ± 173.5	351.0 ± 126.7	< 0.001	407.1 ± 170.3	392.5 ± 146.5	0.065
Potatoes/aroids (g)	44.8 ± 41.9	44.7 ± 42.9	45.0 ± 40.4	0.903	40.0 ± 37.0	52.3 ± 47.6	< 0.001
Soybeans/soy products (g)	68.2 ± 46.7	68.2 ± 48.4	68.1 ± 44.2	0.958	63.6 ± 45.7	75.2 ± 47.4	< 0.001
Fruits (g)	117.9 ± 103.4	112.5 ± 103.8	125.7 ± 102.4	0.011	112.7 ± 103.5	126.1 ± 102.9	0.010
Green-yellow vegetables (g)	125.1 ± 81.8	121.1 ± 84.4	130.9 ± 77.7	0.017	118.5 ± 78.7	135.3 ± 85.5	< 0.001
Other vegetables (g)	165.8 ± 98.4	165.3 ± 101.1	166.5 ± 94.5	0.810	157.9 ± 94.2	178.0 ± 103.4	< 0.001
Mushrooms (g)	12.9 ± 11.8	11.5 ± 11.4	15.0 ± 12.0	< 0.001	12.3 ± 11.4	14.0 ± 12.2	0.005
Seaweeds (g)	16.3 ± 14.4	15.7 ± 14.7	17.1 ± 13.9	0.060	14.9 ± 13.6	18.5 ± 15.3	< 0.001
Meat/processed meat (g)	54.1 ± 42.3	58.1 ± 44.9	48.3 ± 37.4	< 0.001	56.0 ± 41.6	51.1 ± 43.2	0.021
Fish/processed fish(g)	93.5 ± 64.2	96.9 ± 65.8	88.6 ± 61.5	0.010	88.9 ± 62.5	100.6 ± 66.2	< 0.001
Eggs (g)	33.3 ± 25.6	36.1 ± 27.2	29.2 ± 22.6	< 0.001	33.0 ± 25.6	33.7 ± 25.7	0.590
Milk/dairy products (g)	120.4 ± 99.4	125.1 ± 106.3	113.7 ± 88.2	0.018	110.5 ± 94.9	135.8 ± 104.3	< 0.001
Sugar/sweeteners (g)	4.1 ± 3.4	4.3 ± 3.9	3.7 ± 2.5	0.001	4.0 ± 3.5	4.2 ± 3.3	0.219
Sweets/snacks (g)	31.9 ± 33.0	31.7 ± 33.4	32.1 ± 32.4	0.840	32.1 ± 32.7	31.5 ± 33.5	0.702
Oil (g)	8.1 ± 5.3	8.9 ± 5.6	7.0 ± 4.6	< 0.001	8.6 5.6	7.4 4.8	< 0.001
Seasonings (g)	19.2 ± 9.4	20.8 ± 10.0	16.8 ± 7.9	< 0.001	19.2 ± 9.3	19.1 ± 9.6	0.809
Alcoholic beverages (g)	104.2 ± 220.5	162.1 ± 262.5	20.3 ± 85.8	< 0.001	122.1 ± 247.8	76.3 ± 166.1	< 0.001
Other beverages (g)	672.8 ± 347.5	715.4 ± 364.7	611.2 ± 310.9	< 0.001	691.4 ± 355.3	644.0 ± 333.1	0.007

	Duration of diabetes < 10 years ($n=818$)	Duration of diabetes ≥ 10 years ($n=808$)	p value	HbA1c < 7% ($n=710$)	HbA1c ≥ 7% ($n=931$)	p value
	Mean ± SD	Mean ± SD		Mean ± SD	Mean ± SD	
Grains (g)	409.3 ± 168.9	394.5 ± 154.7	0.066	405.7 ± 154.1	398.0 ± 167.1	0.336
Potatoes/aroids (g)	46.6 ± 44.2	43.1 ± 39.7	0.100	47.2 ± 42.9	43.0 ± 41.1	0.043
Soybeans/soy products (g)	66.9 ± 46.5	69.6 ± 47.0	0.240	73.0 ± 48.2	64.5 ± 45.2	< 0.001
Fruits (g)	119.3 ± 107.5	116.6 ± 98.8	0.606	115.8 ± 99.0	119.6 ± 106.8	0.454
Green-yellow vegetables (g)	125.5 ± 82.4	125.3 ± 81.6	0.948	131.0 ± 84.8	120.4 ± 79.3	0.009
Other vegetables (g)	166.8 ± 96.9	165.1 ± 99.8	0.736	172.3 ± 100.2	160.8 ± 96.9	0.020
Mushrooms (g)	13.4 ± 12.0	12.6 ± 11.6	0.175	13.4 ± 12.2	12.6 ± 11.4	0.185
Seaweeds (g)	16.4 ± 14.6	16.2 ± 14.3	0.721	17.3 ± 15.6	15.5 ± 13.4	0.015
Meat/processed meat (g)	56.2 ± 44.9	52.0 ± 39.7	0.045	56.4 ± 43.6	52.4 ± 41.3	0.057
Fish/processed fish(g)	94.7 ± 65.0	92.8 ± 63.7	0.559	99.2 ± 68.4	89.1 ± 60.2	0.002
Eggs (g)	32.7 ± 25.7	33.8 ± 25.6	0.419	33.6 ± 26.6	33.0 ± 24.9	0.645
Milk/dairy products (g)	118.2 ± 97.7	122.9 ± 101.7	0.343	125.0 ± 97.7	117.2 ± 100.6	0.116
Sugar/sweeteners (g)	4.2 ± 3.4	4.0 ± 3.4	0.324	4.1 ± 3.5	4.0 ± 3.3	0.766
Sweets/snacks (g)	32.8 ± 33.8	31.0 ± 32.2	0.284	30.7 ± 32.1	32.8 ± 33.7	0.222
Oil (g)	8.4 ± 5.5	7.9 ± 5.2	0.063	8.4 ± 5.7	7.9 ± 5.0	0.080
Seasonings (g)	19.4 ± 9.3	19.0 ± 9.6	0.362	19.7 ± 9.5	18.8 ± 9.3	0.055
Alcoholic beverages (g)	101.4 ± 216.6	102.9 ± 206.7	0.882	120.1 ± 237.7	92.2 ± 206.0	0.013
Other beverages (g)	671.2 ± 349.5	674.4 ± 347.6	0.852	660.9 ± 337.7	682.6 ± 354.7	0.209

were similar, regardless of gender, age, HbA1c level, and duration of diabetes.

The consumption of fish (93.5 g) and soybean products (68.2 g) were greater than the consumption of meat (54.1 g) and eggs (33.3 g); these trends were also observed in the JDCS patients [8]. The results were regardless of sex, age, HbA1c level and diabetes duration, suggesting that dietary content and food patterns among Japanese patients with type

Table 4 Physical activity of patients with type 2 diabetes who participated in the JDCP Study

	All ($n=1834$) %	Men ($n=1104$) %	Women ($n=730$) %	p value	Age <65 years ($n=1104$) %	Age ≥65 years ($n=730$) %	p value
Physical activity, METs min/week[a]	2186.8 ± 2523.6	2344.5 ± 2700.9	1948.3 ± 2209.3	0.001	2067.8 ± 2427.6	2366.8 ± 2653.7	0.013
Level of physical activity							
High	23.8%	25.0%	21.9%	0.039	22.2%	26.2%	0.006
Moderate	45.2%	46.2%	43.8%		44.1%	47.0%	
Low	31.0%	28.8%	34.3%		33.7%	26.8%	
Category of physical activity							
(1) Vigorous-intensity activity on at least 3 days achieving a minimum Total physical activity of at least 1500 MET-min/week	11.9%	12.5%	11.1%	0.364	10.8%	13.7%	0.059
(2) 7 or more days of any combination of walking, moderate-intensity or vigorous-intensity activities achieving a minimum total physical activity of at least 3000 MET-min/week	21.4%	22.6%	19.5%	0.103	20.1%	23.3%	0.104
(3) 3 or more days of vigorous-intensity activity of at least 20 min per day	12.2%	12.9%	11.2%	0.297	11.1%	14.0%	0.061
(4) 5 or more days of moderate-intensity activity and/or walking of at least 30 min per day	63.8%	65.7%	61.1%	0.046	61.1%	68.1%	0.002
(5) 5 or more days of any combination of walking, moderate-intensity or vigorous intensity activities achieving a minimum total physical activity of at least 600 MET-minutes/week	66.5%	68.8%	62.9%	0.008	63.1%	71.5%	<0.001

	HbA1c <7% ($n=799$) %	HbA1c ≥7% ($n=1032$) %	p value	Duration of diabetes <10 years ($n=906$) %	Duration of diabetes ≥10 years ($n=914$) %	p value
Physical activity, METs min/week[a]	2205.3 ± 2490.9	2172.2 ± 2551.6	0.781	2080.4 ± 2432.2	2302.8 ± 2622.5	0.061
Level of physical activity						

Table 4 (continued)

	HbA1c < 7% (*n* = 799)	HbA1c ≥ 7% (*n* = 1032)	*p* value	Duration of diabetes < 10 years (*n* = 906)	Duration of diabetes ≥ 10 years (*n* = 914)	*p* value
	%	%		%	%	
High	24.3%	23.3%	0.785	22.4%	25.4%	0.288
Moderate	45.5%	45.1%		46.5%	43.6%	
Low	30.2%	31.6%		31.1%	31.0%	
Category of physical activity						
(1) Vigorous-intensity activity on at least 3 days achieving a minimum total physical activity of at least 1500 MET-min/week	12.0%	11.9%	0.950	11.6%	12.5%	0.563
(2) 7 or more days of any combination of walking, moderate-intensity or vigorous-intensity activities achieving a minimum total physical activity of at least 3000 MET-min/week	22.0%	20.8%	0.536	20.0%	23.0%	0.119
(3) 3 or more days of vigorous-intensity activity of at least 20 min per day	12.4%	12.1%	0.857	11.9%	12.7%	0.617
(4) 5 or more days of moderate-intensity activity and/or walking of at least 30 min per day	64.3%	63.5%	0.704	62.7%	64.8%	0.357
(5) 5 or more days of any combination of walking, moderate-intensity or vigorous intensity activities achieving a minimum total physical activity of at least 600 MET-minutes/week	67.3%	65.8%	0.489	66.1%	66.7%	0.778

[a]Mean ± SD

2 diabetes were similar to those in Western countries. The trends are reported to decrease the risk of obesity [32] and type 2 diabetes [33]. Previously, an 8-year nationwide cohort study reported that an elevated incidence of CHD in Japanese patients with type 2 diabetes was associated with high meat intake [34]. In addition, a previous study reported that in Western female nurses with type 2 diabetes, participants with the highest intake of red meat (203 g/ day) had a 1.5-fold higher risk of CHD compared with the lowest intake (47 g/day) [35, 36]. Though it is necessary to note the differences in measurement methods for meat intake among studies, it is suggested that the Japanese patients with type 2 diabetes had a higher incidence of CHD with lower meat consumption compared with the Western female nurses with type 2 diabetes. The results suggest that Japanese patients with type 2 diabetes must pay attention to the source and amount of protein in their diet.

The mean sodium intake in this study was 10.8 g/day, whereas the mean salt intake in the JDCS was 10.7 g/day [8]. The National Health and Nutrition Survey in Japan reported that salt intake in the general Japanese population was 13.7 g/day in 1996 and 11.1 g/day in 2007 [16]. Although differences in the questionnaires used to assess dietary intake can influence the results, it is suggested that the salt intake of Japanese patients with type 2 diabetes is lower than the general Japanese population's intake over the last 10 years. A systematic review has shown that Japan is one of the world's highest consumers of dietary salt [37] and, over the past 10 years, salt intake has not decreased in Japanese patients with type 2 diabetes, even though it has decreased in the general Japanese population. The salt intake is higher in Japanese patients with type 2 diabetes than in patients with diabetes in the United States, which is reported to be 6.5–8.5 g/day [38]. According to the JDCS, the incidence of CVD after an 8-year follow-up was increased 1.7-fold in Japanese patients with type 2 diabetes with high salt intake (15.0 g/day) compared with low salt intake (7.1 g/ day). Among patients who had levels of HbA1c ≥ 9.0%, the hazard ratio for CVD in the low vs high salt intake group was dramatically elevated compared with patients with HbA1c levels < 9.0% (1.2 and 9.9, respectively) [39]. In elderly Japanese patients with type 2 diabetes, a high salt intake combined with low vegetable intake was associated with an elevated incidence of diabetic retinopathy [40]. The results suggest that a further decrease in dietary salt intake is needed for Japanese patients with diabetes to appropriately manage their existing diabetic conditions.

Only 10.5% of the JDCP patients met the daily recommendations for fiber set by JDS (≥ 20 g) [7]: the mean fiber intake was 13.1 g/day. The mean fiber intake of JDCS patients was 14.7 g/day, and 15% ingested 20 g or more of fiber per day [8]. The percentage of patients ingesting 20 g or more of fiber was low in patients younger than 65 years (age < 65 years: 8.5% and age ≥ 65 years: 13.7%, respectively, $p = 0.001$). The results suggest that fiber intake in Japanese patients with type 2 diabetes was continuously below the recommended amount from 1996 to 2007. The mean fiber intake values were similar to those in Western type 2 diabetes patients (11.4–20.5 g/day) [38, 41, 42] and the general Japanese population (15.2 g/day) [16]. The mean vegetable intake for all participants was less than 300 g/day in this study, compared with 324 g/day in JDCS patients surveyed in 1996 [8]. The mean total vegetable intake was low in patients younger than 65 years (276.3 g/day) compared with patients equal to or older than 65 years (313.4 g/day). Low fiber and vegetable intakes contribute to an increased risk of developing diabetic retinopathy and stroke among patients with type 2 diabetes [43, 44]. Increasing fiber intake is continuously recommended to keep diabetes under control, especially for patients younger than 65 years.

Physical activity in patients with type 2 diabetes was also observed and the prevalence of patients who engaged in high, moderate, and low level physical activity was 23.8%, 45.3%, and 31.0%, respectively. The results show that about 30% of Japanese patients with type 2 diabetes do not have any exercise habits, including habitual aerobic exercise. The prevalence of no exercise habits was lower than in patients with diabetes in Australia (57%) [45] and similar to patients with diabetes in Hong Kong (29%) [46]. A previous study reported that the Japanese population are particularly inactive compared to the rest of the world [47]. It is important to raise awareness of the importance of physical activity in Japanese patients with type 2 diabetes, paying particular attention to the group in which physical activity was low. In addition, there are gender differences in physical activity status. Our study showed that weekly physical activity in female patients was lower than in male patients (1948.3 ± 2209.3 and 2344.5 ± 2700.9 METs min/week, respectively, $p < 0.001$) and the percentage of female patients with low physical activity was higher than for male patients (34.2% and 28.8%, respectively). This trend is similar for patients with diabetes in Hong Kong [46]; however, the gender difference in physical activity is reduced in the United States [48]. According to the National Health and Nutrition Survey in Japan of 2007, the percentage of Japanese people regularly engaging in exercise was 29.1% for men, and 25.6% for women, indicating that exercise is not sufficiently widespread, especially among women [49]. In terms of age, Japanese people aged 60 and over were more likely to have exercise habits (men in their 60s: 36.3%, women in their 60s: 40.0%). The age groups with the lowest exercise habits were males in their 30s (18.8%) and females in their 20s (14.1%); exercise habits were more commonly observed in the older participants [49]. This trend is consistent with the results of our current JDCP study: patients younger than 65 years had a higher rate of low physical activity compared with patients equal to or older than 65 years (33.7% and 26.8%, respectively). It is essential to consider these results and increase physical activity in future exercise therapies for Japanese type 2 diabetes patients, especially in women and young patients with type 2 diabetes.

The BMI of Japanese patients with type 2 diabetes increased from 22.7 to 24.1 kg/m^2 in men and 23.2 to 24.8 kg/m^2 in women from 1996 to 2007 [8, 50]; however, there was little difference in BMI in the general Japanese population between 1996 (men 23.0 kg/m^2 and women 22.5 kg/m^2) and 2007 (men 23.6 kg/m^2 and women 22.3 kg/m^2) [49]. The mean proportions of carbohydrate, protein, and fat comprising total energy intake in the general Japanese population during 1996–2007 was similar to that in Japanese patients with type 2 diabetes, with no significant changes: carbohydrate, 58.4% energy and 60.1% energy in 1996 and 2007, respectively; protein, 16.3% energy and 15.0% energy in 1996 and 2007, respectively; fat, 25.3% energy and 24.6% energy in 1996 and 2007, respectively [16]. The mean energy intake of the general Japanese population decreased from 2029 to 1913 kcal/day from 1996 to 2007, respectively [16], whereas Japanese patients with type 2 diabetes from 2007 (JDCP study) had similar energy and nutrient intake status to patients in 1996 (JDCS) [8]. There were no significant differences in physical activity levels and patterns between the general population and patients with diabetes, and the recommended physical activity goals were not achieved, regardless of the presence or absence of diabetes [51, 52]. In addition, the number of steps taken per day by the general Japanese population has substantially decreased for both men and women from 1996 to 2007 (men 7983 and 7427 steps; and women 7007 and 6595 steps, respectively) [49]. Japanese people have become more sedentary since the end of World War II, due to dramatic changes in lifestyle [53]. It can be speculated that during the 10 years from 1996 to 2007, the BMI of Japanese patients with type 2 diabetes has increased because energy intake has remained unchanged despite the decrease in physical activity levels, whereas the BMI of the general Japanese population remained unchanged because both their physical activity levels and energy intakes decreased. In particular, women with type 2 diabetes had a higher BMI (24.8 kg/m^2) in the JDCP study surveyed in 2007 than in the JDCS surveyed in 1996 (23.2 kg/m^2), though the mean energy intake of women with type 2 diabetes was lower in the JDCP study (1491 kcal) compared with the JDCS (1643 kcal), albeit the comparison was through different dietary intake questionnaires [8]. In our current JDCP study, the weekly physical activity was lower in female patients than male patients (1948 and 2345 METs min/week, respectively) and the percentage of female patients with low physical activity was higher than for male patients (34.2% and 28.8%, respectively). The balance between dietary energy intake and energy expenditure based on physical activity is important for patients with type 2 diabetes, especially in female patients.

The present study had several limitations. First, self-recording questionnaires can lead to inaccuracies in participants' reported dietary composition and physical activity status. Previous data suggests that being a woman, being obese, or desiring to reduce bodyweight increase the likelihood of under reporting energy intake [54]. The estimated physical activity levels from the IPAQ are related to over reporting physical activity, leading to an underestimation of the prevalence of insufficient activity [55, 56]. Japanese type 2 diabetic patients had a much lower BMI compared with Western patients [50]. Secondly, 27.6% of participants completed the BDHQ and 30.8% of participants completed the IPAQ; therefore, the differences between those who did and did not complete the questionnaires could have potentially influenced the cross-study comparisons of dietary intake.

In conclusion, we determined the actual dietary intake and physical activity status among Japanese patients with type 2 diabetes under the nationwide JDCP study, launched in 2007. Patients in the JDCP study had similar energy and nutrient intake status to patients in the JDCS, carried out 1996, and had higher carbohydrate consumption and lower fat consumption compared with diabetic patients in Western countries. The JDCP patients consumed excess salt and inadequate fiber intake, suggesting that further decreasing dietary salt intake and increasing fiber intake is necessary. Our study revealed that about 30% of Japanese patients with type 2 diabetes did not have exercise habits; this was particularly noticeable in female patients and patients under the age of 65. The BMI of Japanese patients with type 2 diabetes increased from 22.7 to 24.1 kg/m^2 in men and 23.2 to 24.8 kg/m^2 in women from 1996 to 2007. The reason for this increment is suggested to be due to energy intake remaining unchanged despite a decrease in physical activity level. The balance between dietary energy intake and energy expenditure based on physical activity has become more important in patients with type 2 diabetes in recent years. Based on our findings, more research is needed to investigate how food and nutritional intakes and physical activity among type 2 diabetes patients are associated with the risk of developing complications. It is also necessary to examine how the combination of dietary intake and physical activity is related to the development of complications.

Acknowledgements We thank all the patients, staff and the diabetologists all over Japan for their long-standing collaboration in this study. We thank Satoshi Sasaki, M.D., Ph.D., Professor in the Department of Social and Preventive Epidemiology, School of Public Health, the University of Tokyo, for helpful nutritional advice. Thanks are also extended to Ms. Mami Haga, Niigata University, for their excellent secretarial assistance.

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Funding Funding to support this study was received from Japan Diabetes Society.

Declarations

Conflict of interest Jo Satoh received honoraria from Boehringer Ingelheim, Eli Lilly and Company, MSD, Ono Pharmaceutical Co., Ltd., Sanofi, and Sumitomo Dainippon Pharma Co., Ltd. Yasuaki Hayashino received a research grant from Ono Pharmaceutical Co., Ltd. Rimei Nishimura received honoraria from Sanofi, Medtronic Japan Co., Ltd., Nippon Boehringer Ingelheim Co., Ltd., Takeda Pharmaceutical Co., Ltd., Eli Lilly Japan K.K., Novo Nordisk Pharma Ltd., MSD, and Astellas Pharma Inc., and received subsidies or donations from Taisho Pharmaceutical Co., Ltd., Ono Pharmaceutical Co., Ltd., Takeda Pharmaceutical Company Ltd., and Nippon Boehringer Ingelheim Co., Ltd. Hirohito Sone received a research grant from Novo Nordisk Pharma

Ltd., and reports endowed departments by commercial entities from Novo Nordisk Pharma Ltd., Eisai Co., Ltd., Kyowa Kirin Co., Ltd. Astellas Pharma Inc., Taisho Pharmaceutical Co., Ltd., Ono Pharmaceutical Co., Ltd., and Takeda Pharmaceutical Co., Ltd. Chika Horikawa, Kinsuke Tsuda, Yoshiharu Oshida, and Naoko Tajima declare that they have no conflict of interest.

Ethical considerations 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 the Japan Diabetes Society Research Ethics Committee and all of the participating institutes, and was registered with the UMIN Clinical Trial Registry (Registry ID UMIN000016519).

Informed consent Written informed consent was obtained from all patients enrolled to protect their rights and welfare, and to protect them against any potential harm and risk associated with the conduct of the study.

References

1. Davies MJ, D'Alessio DA, Fradkin J, et al. Management of hyperglycemia in type 2 diabetes, 2018. A consensus report by the American Diabetes Association (ADA) and the European Association for the Study of Diabetes (EASD). Diabetes Care. 2018;41(12):2669–701.
2. Wing RR, Bolin P, Brancati FL, et al. Cardiovascular effects of intensive lifestyle intervention in type 2 diabetes. N Engl J Med. 2013;369(2):145–54.
3. Franz MJ, Boucher JL, Rutten-Ramos S, VanWormer JJ. Lifestyle weight-loss intervention outcomes in overweight and obese adults with type 2 diabetes: a systematic review and meta-analysis of randomized clinical trials. J Acad Nutr Diet. 2015;115(9):1447–63.
4. Hatta M, Fujihara K, Morikawa SY, et al. Combined effects of energy intake and physical activity on obesity in Japanese patients with type 2 diabetes (JDDM 50): a cross-sectional study. Diabetes Ther. 2019;10(3):1133–8.
5. Espeland MA, Glick HA, Bertoni A, et al. Impact of an intensive lifestyle intervention on use and cost of medical services among overweight and obese adults with type 2 diabetes: the action for health in diabetes. Diabetes Care. 2014;37(9):2548–56.
6. Evert AB, Dennison M, Gardner CD, et al. Nutrition therapy for adults with diabetes or prediabetes: a consensus report. Diabetes Care. 2019;42(5):731–54.
7. Araki E, Goto A, Kondo T, et al. Japanese clinical practice guideline for diabetes 2019. Diabetol Int. 2020;11(3):165–223.
8. Horikawa C, Yoshimura Y, Kamada C, et al. Dietary intake in Japanese patients with type 2 diabetes: analysis from Japan Diabetes Complications Study. J Diabetes Investig. 2014;5(2):176–87.
9. Sone H, Tanaka S, Suzuki S, et al. Leisure-time physical activity is a significant predictor of stroke and total mortality in Japanese patients with type 2 diabetes: analysis from the Japan Diabetes Complications Study (JDCS). Diabetologia. 2013;56(5):1021–30.
10. Tanaka S, Iimuro S, Yamashita H, et al. Cohort profile: the Japan diabetes complications study: a long-term follow-up of a randomised lifestyle intervention study of type 2 diabetes. Int J Epidemiol. 2014;43(4):1054–62.
11. Araki A, Iimuro S, Sakurai T, et al. Long-term multiple risk factor interventions in Japanese elderly diabetic patients: the Japanese Elderly Diabetes Intervention Trial—study design, baseline characteristics and effects of intervention. Geriatr Gerontol Int. 2012;12(Suppl 1):7–17.
12. Yoshimura Y, Kamada C, Takahashi K, et al. Relations of nutritional intake to age, sex and body mass index in Japanese elderly patients with type 2 diabetes: the Japanese Elderly Diabetes Intervention Trial. Geriatr Gerontol Int. 2012;12(Suppl 1):29–40.
13. Iijima K, Iimuro S, Shinozaki T, et al. Lower physical activity is a strong predictor of cardiovascular events in elderly patients with type 2 diabetes mellitus beyond traditional risk factors: the Japanese Elderly Diabetes Intervention Trial. Geriatr Gerontol Int. 2012;12(Suppl 1):77–87.
14. Casagrande SS, Cowie CC. Trends in dietary intake among adults with type 2 diabetes: NHANES 1988–2012. J Hum Nutr Diet. 2017;30(4):479–89.
15. Cruz AF, Calle-Pascual AL, Diabetes and Nutrition Study Group SaDA. Diabetes Nutrition and Complications Trial: Trends in nutritional pattern between 1993 and 2000 and targets of diabetes treatment in a sample of Spanish people with diabetes. Diabetes Care. 2004;27(4):984–7.
16. Ministry of Health, Labour, and Welfare, Japan. National Health and Nutrition Survey. Nutritional Intake Status Survey. https://www.nibiohn.go.jp/eiken/kenkounippon21/en/eiyouchousa/keinen_henka_eiyou_select.html. Accessed 6 Dec 2021.
17. World Health Organization. Global health risks: mortality and burden of disease attributable to selected major risks. https://www.who.int/healthinfo/global_burden_disease/GlobalHealthRisks_report_full.pdf. Accessed 6 Dec 2021.
18. World Health Organization. Global recommendations on physical activity for health. https://www.who.int/dietphysicalactivity/global-PA-recs-2010.pdf. Accessed 6 Dec 2021.
19. Praet SF, van Loon LJ. Exercise therapy in type 2 diabetes. Acta Diabetol. 2009;46(4):263–78.
20. Arakawa S, Watanabe T, Sone H, et al. The factors that affect exercise therapy for patients with type 2 diabetes in Japan: a nationwide survey. Diabetol Int. 2015;6:19–25.
21. Tajima N, Nishimura R, Izumi K, et al. A large-scale, observational study to investigate the current status of diabetes complications and their prevention in Japan: research outline and baseline data for type 2 diabetes—JDCP study 1. Diabetol Int. 2015;6:243–51.
22. Nishimura R, Izumi K, Hayashino Y, et al. A large-scale observational study to investigate the current status of diabetes complications and their prevention in Japan: research outline and baseline data for type 1 diabetes-JDCP study 2. Diabetol Int. 2016;7(1):4–11.
23. Kawasaki R, Kitano S, Sato Y, et al. Factors associated with non-proliferative diabetic retinopathy in patients with type 1 and type 2 diabetes: the Japan Diabetes Complication and its Prevention prospective study (JDCP study 4). Diabetol Int. 2019;10(1):3–11.
24. Shikata K, Kodera R, Utsunomiya K, et al. Prevalence of albuminuria and renal dysfunction, and related clinical factors in Japanese patients with diabetes: the Japan Diabetes Complication and its Prevention prospective study 5. J Diabetes Investig. 2020;11(2):325–32.
25. Inagaki K, Kikuchi T, Noguchi T, et al. A large-scale observational study to investigate the current status of diabetic complications and their prevention in Japan (JDCP study 6): baseline dental and oral findings. Diabetol Int. 2021;12(1):52–61.
26. Kobayashi S, Murakami K, Sasaki S, et al. Comparison of relative validity of food group intakes estimated by comprehensive and brief-type self-administered diet history questionnaires against 16 d dietary records in Japanese adults. Public Health Nutr. 2011;14(7):1200–11.
27. Kobayashi S, Honda S, Murakami K, et al. Both comprehensive and brief self-administered diet history questionnaires satisfactorily rank nutrient intakes in Japanese adults. J Epidemiol. 2012;22(2):151–9.

28. Craig CL, Marshall AL, Sjöström M, et al. International physical activity questionnaire: 12-country reliability and validity. Med Sci Sports Exerc. 2003;35(8):1381–95.
29. Nakawatase Y, Taru C, Tsutou A, et al. Development of an evaluation scale for self-management behavior related to physical activity of type 2 diabetic patients. Diabetes Care. 2007;30(11):2843–8.
30. Science and Technology Agency, Japan. Standard Tables of Food Composition in Japan, 5th revised and enlarged edition. National Printing Bureau, Japan; 2005.
31. International Physical Activity Questionnaire. Guidelines for the data processing and analysis of the "International Physical Activity Questionnaire". https://docs.google.com/viewer?a=v&pid=sites&srcid=ZGVmYXVsdGRvbWFpbnx0aGVpcGFxfGd4OjE0NDgxMDk3NDU1YWRlZTM. Accessed 6 Dec 2021.
32. Schulze MB, Fung TT, Manson JE, Willett WC, Hu FB. Dietary patterns and changes in body weight in women. Obesity (Silver Spring). 2006;14(8):1444–53.
33. Montonen J, Knekt P, Härkänen T, et al. Dietary patterns and the incidence of type 2 diabetes. Am J Epidemiol. 2005;161(3):219–27.
34. Horikawa C, Kamada C, Tanaka S, et al. Meat intake and incidence of cardiovascular disease in Japanese patients with type 2 diabetes: analysis of the Japan Diabetes Complications Study (JDCS). Eur J Nutr. 2019;58(1):281–90.
35. Qi L, van Dam RM, Rexrode K, Hu FB. Heme iron from diet as a risk factor for coronary heart disease in women with type 2 diabetes. Diabetes Care. 2007;30(1):101–6.
36. Pan A, Sun Q, Bernstein AM, et al. Red meat consumption and risk of type 2 diabetes: 3 cohorts of US adults and an updated meta-analysis. Am J Clin Nutr. 2011;94(4):1088–96.
37. Powles J, Fahimi S, Micha R, et al. Global, regional and national sodium intakes in 1990 and 2010: a systematic analysis of 24 h urinary sodium excretion and dietary surveys worldwide. BMJ Open. 2013;3(12):e003733.
38. Eilat-Adar S, Xu J, Zephier E, O'Leary V, Howard BV, Resnick HE. Adherence to dietary recommendations for saturated fat, fiber, and sodium is low in American Indians and other U.S. adults with diabetes. J Nutr. 2008;138(9):1699–704.
39. Horikawa C, Yoshimura Y, Kamada C, et al. Dietary sodium intake and incidence of diabetes complications in Japanese patients with type 2 diabetes: analysis of the Japan Diabetes Complications Study (JDCS). J Clin Endocrinol Metab. 2014;99(10):3635–43.
40. Horikawa C, Aida R, Tanaka S, et al. Sodium intake and incidence of diabetes complications in elderly patients with type 2 diabetes-analysis of data from the Japanese Elderly Diabetes Intervention Study (J-EDIT). Nutrients. 2021;13(2):689.
41. The Diabetes and Nutrition Study Group of the Spanish Diabetes Association (GSEDNu). Diabetes nutrition and complications trial (DNCT): food intake and targets of diabetes treatment in a sample of Spanish people with diabetes. Diabetes Care. 1997;20(7):1078–80.
42. Ma Y, Olendzki BC, Hafner AR, et al. Low-carbohydrate and high-fat intake among adult patients with poorly controlled type 2 diabetes mellitus. Nutrition. 2006;22(11–12):1129–36.
43. Tanaka S, Yoshimura Y, Kamada C, et al. Intakes of dietary fiber, vegetables, and fruits and incidence of cardiovascular disease in Japanese patients with type 2 diabetes. Diabetes Care. 2013;36(12):3916–22.
44. Tanaka S, Yoshimura Y, Kawasaki R, et al. Fruit intake and incident diabetic retinopathy with type 2 diabetes. Epidemiology. 2013;24(2):204–11.
45. Nolan RC, Raynor AJ, Berry NM, May EJ. Self-reported physical activity using the International Physical Activity Questionnaire (IPAQ) in Australian adults with type 2 diabetes, with and without peripheral neuropathy. Can J Diabetes. 2016;40(6):576–9.
46. Hui SS, Hui GP, Xie YJ. Association between physical activity knowledge and levels of physical activity in Chinese adults with type 2 diabetes. PLoS ONE. 2014;9(12):e115098.
47. Guthold R, Stevens GA, Riley LM, Bull FC. Worldwide trends in insufficient physical activity from 2001 to 2016: a pooled analysis of 358 population-based surveys with 1·9 million participants. Lancet Glob Health. 2018;6(10):e1077–86.
48. Morrato EH, Hill JO, Wyatt HR, Ghushchyan V, Sullivan PW. Physical activity in U.S. adults with diabetes and at risk for developing diabetes, 2003. Diabetes Care. 2007;30(2):203–9.
49. Ministry of Health, Labour, and Welfare, Japan. National Health and Nutrition Survey. Physical Status Questionnaire. https://www.nibiohn.go.jp/eiken/kenkounippon21/en/eiyouchousa/keinen_henka_shintai.html. Accessed 6 Dec 2021.
50. Sone H, Ito H, Ohashi Y, Akanuma Y, Yamada N, Group JDCS. Obesity and type 2 diabetes in Japanese patients. Lancet. 2003;361(9351):85.
51. Ford ES, Herman WH. Leisure-time physical activity patterns in the U.S. diabetic population. Findings from the 1990 National Health Interview Survey-Health Promotion and Disease Prevention Supplement. Diabetes Care. 1995;18(1):27–33.
52. Morino K, Kondo K, Tanaka S, et al. Total energy expenditure is comparable between patients with and without diabetes mellitus: Clinical Evaluation of Energy Requirements in Patients with Diabetes Mellitus (CLEVER-DM) Study. BMJ Open Diabetes Res Care. 2019;7(1):e000648.
53. Kawamori R. Diabetes trends in Japan. Diabetes Metab Res Rev. 2002;18(Suppl 3):S9-13.
54. Johansson L, Solvoll K, Bjørneboe GE, Drevon CA. Under- and overreporting of energy intake related to weight status and lifestyle in a nationwide sample. Am J Clin Nutr. 1998;68(2):266–74.
55. Rzewnicki R, Vanden Auweele Y, De Bourdeaudhuij I. Addressing overreporting on the International Physical Activity Questionnaire (IPAQ) telephone survey with a population sample. Public Health Nutr. 2003;6(3):299–305.
56. Ainsworth BE, Macera CA, Jones DA, et al. Comparison of the 2001 BRFSS and the IPAQ Physical Activity Questionnaires. Med Sci Sports Exerc. 2006;38(9):1584–92.