JDI Journal of Diabetes Investigation Open access
Official Journal of the Asian Association for the Study of Diabetes
ORIGINAL ARTICLE

Dietary intake habits and the prevalence of nocturia in Japanese patients with type 2 diabetes mellitus

Shinya Furukawa[1,2]*, Takenori Sakai[3], Tetsuji Niiya[4], Hiroaki Miyaoka[5], Teruki Miyake[6], Shin Yamamoto[7], Koutatsu Maruyama[8], Keiko Tanaka[1,2], Teruhisa Ueda[9], Hidenori Senba[1,6], Masamoto Torisu[10], Hisaka Minami[11], Takeshi Tanigawa[12], Bunzo Matsuura[7], Yoichi Hiasa[6], Yoshihiro Miyake[1,2]

[1]Department of Epidemiology and Preventive Medicine, Ehime University Graduate School of Medicine, [2]Epidemiology and Medical Statistics Unit, Translational Research Center, Ehime University Hospital, [3]Department of Internal Medicine, Yawatahama General City Hospital, [4]Department of Internal Medicine, Matsuyama Shimin Hospital, [5]Department of Internal Medicine, Saiseikai Matsuyama Hospital, Departments of [6]Gastroenterology and Metabology, [7]Lifestyle-Related Medicine and Endocrinology, Ehime University Graduate School of Medicine, [8]Laboratory of Community Health and Nutrition, Special Course of Food and Health Science, Department of Bioscience, Graduate School of Agriculture, Ehime University, [9]Department of Internal Medicine, Ehime Prefectural Central Hospital, [10]Department of Internal Medicine, Saiseikai Saijo Hospital, [11]Department of Internal Medicine, Ehime Niihama Hospital, Ehime, and [12]Department of Public Health, Juntendo University School of Medicine, Tokyo, Japan

Keywords
Dietary behavior, Nocturia, Vegetable

***Correspondence**
Shinya Furukawa
Tel.: +81-89-960-5283
Fax: +81-89-960-5384
E-mail address:
shinya.furukawa@gmail.com

J Diabetes Investig 2018; 9: 279–285

doi: 10.1111/jdi.12709

ABSTRACT

Aims/Introduction: No reports have been published on the association between dietary intake habits and nocturia in the diabetes population. We therefore evaluated this issue among Japanese patients with diabetes mellitus.

Materials and Methods: Study participants in the present study were 785 Japanese patients with type 2 diabetes mellitus. Self-administered questionnaires were used to assess each type of dietary intake habit. Vegetable intake habit was assessed by the following question: "*Do you have vegetables or seaweed every day?*" We used the following two outcomes: (i) nocturia: ≥2 voids per night; and (ii) severe nocturia: ≥3 voids per night. Adjustment was made for age, sex, body mass index, glycated hemoglobin, hypertension, dyslipidemia, smoking, drinking, exercise habit, stroke, ischemic artery disease, diabetic nephropathy, diabetic neuropathy and diabetic retinopathy.

Results: The prevalence of nocturia, severe nocturia, and vegetable intake habit was 39.9%, 14.4% and 67.3%, respectively. After adjusting for confounding factors, vegetable intake habit was independently inversely associated with nocturia and severe nocturia: the adjusted odds ratios were 0.67 (95% confidence interval [CI] 0.48–0.94) and 0.46 (95% CI 0.30–0.71), respectively. Among male patients, vegetable intake habit was independently inversely associated with severe nocturia, but not nocturia: the adjusted OR was 0.51 (95% CI 0.29–0.88). Among female patients, vegetable intake habit was independently inversely associated with nocturia and severe nocturia: the adjusted ORs were 0.44 (95% CI 0.24–0.79) and 0.34 (95% CI 0.15–0.78), respectively.

Conclusions: We found an inverse association between vegetable intake habit and nocturia in Japanese patients with type 2 diabetes mellitus.

INTRODUCTION

Nocturia, one type of voiding dysfunction, negatively affects nocturnal sleep, daytime sleepiness and quality of life. Nocturia is common among patients with diabetes mellitus. Among Japanese patients with type 2 diabetes mellitus, nocturia was significantly positively associated with erectile dysfunction[1], diabetic retinopathy[2] and depressive symptoms[3].

Among the general population, some evidence exists regarding the relationship between dietary intake and voiding dysfunction including lower urinary tract symptoms (LUTS), overactive bladder (OAB) and benign prostate hyperplasia (BPH). Intake levels of vegetables[4–9], vegetable fat[6],

Received 23 March 2017; revised 24 June 2017; accepted 28 June 2017

isoflavones[7] and citrus juice[8] were significantly inversely associated with LUTS, whereas a significant positive relationship between total energy intake and LUTS was found[9]. Inverse associations between the intake of vegetables, bread and chicken and OAB were observed[10]. Intake levels of vitamin D, protein and potassium, as well as beer intake, were significantly inversely associated with the onset of OAB[11,12]. Intake levels of vegetables and vegetable fat were significantly inversely associated with BPH[7,13–16].

No data regarding the association between dietary intake and nocturia are available among patients with type 2 diabetes mellitus. The importance of research into the possible role of dietary factors in voiding dysfunction is emphasized by the fact that diet is modifiable. The aim of the present study was to evaluate the association between dietary intake habits and nocturia among Japanese patients with type 2 diabetes mellitus.

METHODS

Study population

The Dogo Study is an ongoing multicenter prospective cohort study of patients with diabetes. All 1051 Japanese patients with type 2 diabetes mellitus who gave informed consent were enrolled from the participating local base hospitals in Ehime prefecture. The patients in this cohort study were recruited from 2009 to 2014. The final analysis sample in this study consisted of 785 patients, as 266 patients were excluded due to incomplete data. The present study protocol conforms to the ethical guidelines of the 1975 Declaration of Helsinki as reflected in a priori approval by the institutional review board of the Ehime University Graduate School of Medicine.

Measurements

Each participant completed a self-administered questionnaire, which collected data on the variables. Information on medication was based on admission records, medical records and/or a questionnaire. Exercise habit was defined as positive if the study participants reported exercising 60 min or more per week during leisure time, regardless of the exercise intensity. The definitions of variables were previously described in detail[1–3]. The definitions of microvascular diseases were based on the Classification of Diabetic Nephropathy 2014[17,18], the Fukuda standard[19] and the abbreviated diagnosis of diabetic neuropathy[20].

Assessment of dietary intake habits

We used a self-administered questionnaire to estimate dietary intake using the following questions: (i) "*Do you have fried food every day?*"; (ii) "*Do you have one or more eggs every day?*"; (iii) "*Do you have meat more than twice a week?*"; (iv) "*Do you have fish or shellfish more than twice a week?*"; (v) "*Do you have salty pickles more than twice a day?*"; (vi) "*Do you have vegetables or seaweed every day?*"; (vii) "*Do you have fruit every day?*"; (viii) "*Do you have soy products every day?*"; and (ix) "*Do you consume dairy products every day?*". Patients answered either "yes" or "no"[21,22].

Assessment of nocturia

The definition of nocturia was based on a questionnaire regarding the numbers of voids[1–3]. We used the following outcomes: (i) nocturia was defined as ≥2 voids per night; and (ii) severe nocturia was defined as ≥3 voids per night.

Statistical analysis

We selected age, sex, body mass index, glycated hemoglobin, hypertension, dyslipidemia, current smoking, current drinking, exercise habit, stroke, ischemic artery disease, diabetic nephropathy, diabetic neuropathy and diabetic retinopathy as a priori as potential confounding factors. Logistic regression analyses were carried out to estimate crude odds ratios (ORs) and their 95% confidence intervals (CIs) for nocturia according to dietary intake habits. Additionally, multiple logistic regression analysis was carried out to adjust for confounding factors. All computations were carried out using SAS software package version 9.4 (SAS Institute Inc., Cary, NC, USA).

Table 1 | Clinical characteristics of the 785 study participants

Variable	*n* (%)
Age, years (mean ± SD)	61.7 ± 11.2
Male (%)	489 (62.3)
BMI, kg/m^2 (mean ± SD)	25.2 ± 4.8
HbA1c, % (mean ± SD)	7.89 ± 1.83
Duration of type 2 diabetes mellitus, years (mean ± SD)	11.0 ± 10.2
Current drinking (%)	323 (41.2)
Current smoking (%)	144 (18.3)
Exercise habit	258 (32.9)
Use of diuretics	89 (11.3)
Hypertension (%)	551 (70.2)
Dyslipidemia (%)	585 (74.5)
Diabetic neuropathy (%)	483 (61.5)
Diabetic retinopathy (%)	231 (29.4)
Diabetic nephropathy (%)	80 (10.2)
Stroke (%)	53 (6.8)
Ischemic heart disease (%)	89 (11.3)
Nocturia	
Nocturia, ≥2 voids per night (%)	313 (39.9)
Severe nocturia, ≥3 voids per night (%)	113 (14.4)
Dietary intake habits	
Fried foods (%)	174 (24.7)
Eggs (%)	329 (41.9)
Fatty meat (%)	238 (30.3)
Seafood (%)	553 (70.5)
Pickles (%)	248 (31.6)
Vegetables (%)	528 (67.3)
Fruit (%)	432 (55.0)
Soy products (%)	473 (60.3)
Dairy products (%)	460 (58.6)

BMI, body mass index; Hb1Ac, glycated hemoglobin; SD, standard deviation.

RESULTS

Characteristics of the 785 patients are listed in Table 1. The prevalence of nocturia and severe nocturia was 39.9% and 14.4%, respectively. Dietary intake habits of fried foods, eggs, fatty meat, seafood, pickles, vegetables, fruit, soy products, and dairy products were reported at 24.7%, 41.9%, 30.3%, 70.5%, 31.6%, 67.3%, 55.0%, 60.3% and 58.6% of study participants, respectively. The percentage intake of fish, fruit, soy products and dairy products among patients with vegetable intake habit was significantly low among all patients (data not shown). Table 2 shows the crude and adjusted ORs and 95% CIs for nocturia in relation to dietary intake habits among the 785 patients. In the crude analysis, seafood, fruit and dairy products intake habits were positively associated with nocturia. The association between seafood, fruit, and dairy products and nocturia completely disappeared after adjusting for age, sex, body mass index, glycated hemoglobin, hypertension, dyslipidemia, current smoking, current drinking, exercise habits, stroke, ischemic artery disease, diabetic nephropathy, diabetic neuropathy and diabetic retinopathy. After adjustment, vegetable intake habit was independently inversely associated with nocturia: the adjusted OR was 0.67 (95% CI 0.48–0.94). Table 3 shows the crude and adjusted ORs and 95% CIs for severe nocturia in relation to dietary intake habits. In crude analysis, fruit and daily products intake habits were positively associated with severe nocturia, whereas vegetable intake was inversely associated with severe nocturia. After adjustment, vegetable intake habit was independently inversely associated with severe nocturia: the adjusted OR was 0.46 (95% CI 0.30–0.71). Among male patients, vegetable intake habit was independently inversely associated with severe nocturia, but not nocturia: the adjusted OR was 0.51 (95% CI 0.29–0.88; Table 4). Among female patients, vegetable intake habit was independently inversely associated with nocturia and severe nocturia: the adjusted ORs

Table 2 | Crude and adjusted odds ratios and 95% confidence intervals for nocturia in relation to dietary intake habits among all patients

Variable	Prevalence (%)	Crude OR (95% CI)	Adjusted OR (95% CI)
Nocturia			
Fried foods (%)			
No	242/5,941 (41.0)	1.00	1.00
Yes	71/194 (36.6)	0.83 (0.59–1.16)	1.12 (0.77–1.61)
Eggs (%)			
No	185/456 (40.6)	1.00	1.00
Yes	128/329 (38.9)	0.93 (0.70–1.25)	1.03 (0.76–1.40)
Fatty meat (%)			
No	217/547 (39.7)	1.00	1.00
Yes	96/238 (40.3)	1.03 (0.75–1.40)	1.33 (0.94–1.87)
Seafood (%)			
No	74/232 (31.9)	1.00	1.00
Yes	239/553 (43.2)	1.63 (1.18–2.25)	1.22 (0.86–1.73)
Pickles (%)			
No	202/537 (37.6)	1.00	1.00
Yes	111/248 (44.8)	1.34 (0.99–1.82)	1.11 (0.79–1.54)
Vegetables (%)			
No	110/257 (42.8)	1.00	1.00
Yes	203/528 (38.5)	0.84 (0.62–1.13)	0.67 (0.48–0.94)
Fruit (%)			
No	121/353 (34.3)	1.00	1.00
Yes	192/432 (44.4)	1.53 (1.15–2.05)	1.08 (0.78–1.50)
Soy products (%)			
No	122/312 (39.1)	1.00	1.00
Yes	191/473 (40.4)	1.06 (0.79–1.41)	0.95 (0.69–1.30)
Dairy products (%)			
No	113/325 (34.8)	1.00	1.00
Yes	200/460 (43.5)	1.44 (1.08–1.94)	1.25 (0.91–1.71)

Odds ratios (OR) were adjusted for age, sex, body mass index, glycated hemoglobin, hypertension, dyslipidemia, current smoking, current drinking, exercise habit, stroke, ischemic artery disease, diabetic nephropathy, diabetic neuropathy and diabetic retinopathy. CI, confidence interval.

Table 3 | Crude and adjusted odds ratios and 95% confidence intervals for severe nocturia in relation to dietary intake habits among all patients

Variable	Prevalence (%)	Crude OR (95% CI)	Adjusted OR (95% CI)
Severe nocturia			
Fried foods (%)			
No	88/591 (14.9)	1.00	1.00
Yes	25/194 (12.9)	0.85 (0.52–1.34)	0.99 (0.58–1.65)
Eggs (%)			
No	71/456 (15.6)	1.00	1.00
Yes	42/329 (12.8)	0.79 (0.52–1.19)	0.87 (0.56–1.33)
Fatty meat (%)			
No	79/547 (14.4)	1.00	1.00
Yes	34/238 (14.3)	0.99 (0.63–1.51)	1.16 (0.72–1.84)
Seafood (%)			
No	26/232 (11.2)	1.00	1.00
Yes	87/553 (15.7)	1.48 (0.94–2.40)	1.09 (0.72–1.84)
Pickles (%)			
No	202/537 (37.6)	1.00	1.00
Yes	111/248 (44.8)	1.22 (0.78–1.85)	1.05 (0.67–1.64)
Vegetables (%)			
No	51/257 (19.8)	1.00	1.00
Yes	62/528 (11.7)	0.54 (0.36–0.81)	0.46 (0.30–0.71)
Fruit (%)			
No	39/353 (11.1)	1.00	1.00
Yes	74/432 (17.1)	1.66 (1.10–2.54)	1.31 (0.83–2.09)
Soy products (%)			
No	122/312 (39.1)	1.00	1.00
Yes	191/473 (40.4)	1.00 (0.67–1.50)	0.99 (0.64–1.54)
Dairy products (%)			
No	41/325 (12.6)	1.00	1.00
Yes	72/460 (15.7)	1.29 (0.86–1.96)	1.11 (0.72–1.73)

Odds ratios (OR) were adjusted for age, sex, body mass index, glycated hemoglobin, hypertension, dyslipidemia, current smoking, current drinking, exercise habit, stroke, ischemic artery disease, diabetic nephropathy, diabetic neuropathy and diabetic retinopathy. CI, confidence interval.

Table 4 | Crude and adjusted odds ratios and 95% confidence intervals for severe nocturia in relation to dietary intake among male patients

Variable	Prevalence (%)	Crude OR (95% CI)	Adjusted OR (95% CI)
Nocturia			
Fried foods (%)			
No	151/350 (43.1)	1.00	1.00
Yes	55/139 (39.6)	086 (0.58–1.29)	1.26 (0.80–1.99)
Eggs (%)			
No	122/273 (44.7)	1.00	1.00
Yes	84/216 (38.9)	0.79 (0.55–1.13)	0.93 (0.63–1.38)
Fatty meat (%)			
No	143/344 (41.6)	1.00	1.00
Yes	63/145 (43.5)	1.08 (0.73–1.60)	1.46 (0.93–2.30)
Seafood (%)			
No	49/145 (33.8)	1.00	1.00
Yes	157/344 (45.6)	1.65 (1.10–2.48)	1.16 (0.75–1.81)
Pickles (%)			
No	132/336 (39.3)	1.00	1.00
Yes	74/153 (48.4)	1.45 (0.98–2.13)	1.20 (0.79–1.83)
Vegetables (%)			
No	74/178 (41.6)	1.00	1.00
Yes	132/311 (42.4)	1.04 (0.71–1.51)	0.81 (0.53–1.23)
Fruit (%)			
No	90/241 (37.3)	1.00	1.00
Yes	116/248 (46.8)	1.47 (1.03–2.12)	0.93 (0.61–1.40)
Soy products (%)			
No	88/212 (41.5)	1.00	1.00
Yes	118/277 (42.6)	1.05 (0.73–1.50)	0.91 (0.61–1.35)
Dairy products (%)			
No	82/219 (37.4)	1.00	1.00
Yes	124/270 (45.9)	1.42 (0.99–2.05)	1.12 (0.75–1.66)
Severe nocturia			
Fried foods (%)			
No	51/336 (15.2)	1.00	1.00
Yes	28/153 (18.3)	0.71 (0.39–1.22)	0.83 (0.43–1.55)
Eggs (%)			
No	50/273 (18.3)	1.00	1.00
Yes	29/216 (13.4)	0.69 (0.42–1.13)	0.83 (0.48–1.40)
Fatty meat (%)			
No	54/344 (15.7)	1.00	1.00
Yes	25/145 (17.2)	1.22 (0.66–1.86)	1.19 (0.65–2.14)
Seafood (%)			
No	17/145 (11.7)	1.00	1.00
Yes	62/344 (18.0)	1.66 (0.95–3.02)	1.14 (0.62–2.17)
Pickles (%)			
No	51/336 (15.2)	1.00	1.00
Yes	28/153 (18.3)	1.25 (0.74–2.06)	1.15 (0.65–2.00)
Vegetables (%)			
No	36/178 (20.2)	1.00	1.00
Yes	43/311 (13.8)	0.63 (0.39–1.03)	0.51 (0.29–0.88)
Fruit (%)			
No	32/241 (13.3)	1.00	1.00
Yes	47/248 (19.0)	1.53 (0.94–2.51)	0.98 (0.56–1.72)
Soy products (%)			
No	32/212 (15.1)	1.00	1.00
Yes	47/277 (17.0)	1.15 (0.71–1.89)	1.12 (0.66–1.93)
Dairy products (%)			
No	30/219 (13.7)	1.00	1.00
Yes	49/270 (18.2)	1.40 (0.86–2.31)	1.05 (0.62–1.81)

Odds ratios (OR) were adjusted for age, body mass index, glycated hemoglobin, hypertension, dyslipidemia, current smoking, current drinking, exercise habit, stroke, ischemic artery disease, diabetic nephropathy, diabetic neuropathy and diabetic retinopathy. CI, confidence interval.

were 0.44 (95% CI 0.24–0.79) and 0.34 (95% CI 0.15–0.78), respectively (Table 5). In sensitive analysis, the use of diuretics was independently positively associated with nocturia, but not severe nocturia in all patients. Among patients with good glucose control (glycated hemoglobin <6.5%), the 1.5-anhydroglucitol level among patients with vegetable intake habit was significantly higher than that without.

DISCUSSION

To our knowledge, the present study is the first to show a significant inverse association between vegetable intake habit and nocturia and severe nocturia among Japanese patients with type 2 diabetes mellitus.

In the general population, some evidence of the association between intake of vegetables and voiding dysfunction exists. Vegetable intake was significantly inversely associated with LUTS in a Chinese study of 1,564 men[4], in a Finnish study of 3,143 men[5], in a Chinese study of 2,000 men[7] and in three USA studies[6,8,9]. Similarly, in a USA study of 7,043 women, vegetable intake was significantly inversely associated with OAB[10]. In USA studies of 51,529 men[6], 4,770 men[13], 32,265 men[14] and in a case–control study of Japanese men[15], an inverse association between vegetable intake and BPH was reported. In contrast, in a Greek study of 430 men, vegetable intake was not associated with BPH[23]. The present results are partially consistent with those of the previous studies regarding voiding dysfunction. The discrepancies among these studies might be explained, at least in part, by differences in sample size; the definition of voiding dysfunction; characteristics, such as age, sex, race, body mass index, prevalence of stroke and hypertension; and other confounding factors.

The associations between several types of dietary intake excluding vegetables and voiding dysfunction were observed. In a UK study of 7,043 women, intake of bread and chicken was significantly inversely associated with the onset of OAB[10]. In a USA study of 1,545 men aged 30–79 years, intake of total energy and sodium were significantly positively associated with

Table 5 | Crude and adjusted odds ratios and 95% confidence intervals for severe nocturia in relation to dietary intake among female patients

Variable	Prevalence (%)	Crude OR (95% CI)	Adjusted OR (95% CI)
Nocturia			
Fried foods (%)			
No	91/241 (37.8)	1.00	1.00
Yes	16/55 (29.1)	0.68 (0.35–1.26)	0.86 (0.43–1.67)
Eggs (%)			
No	63/183 (34.4)	1.00	1.00
Yes	44/113 (38.9)	1.22 (0.75–1.97)	1.29 (0.77–2.17)
Fatty meat (%)			
No	74/203 (36.5)	1.00	1.00
Yes	33/93 (35.5)	0.96 (0.57–1.59)	1.13 (0.65–1.95)
Seafood (%)			
No	28/87 (28.7)	1.00	1.00
Yes	82/209 (39.2)	1.60 (0.94–2.79)	1.31 (0.73–2.39)
Pickles (%)			
No	70/201 (34.8)	1.00	1.00
Yes	37/95 (39.0)	1.19 (0.72–1.97)	0.97 (0.56–1.65)
Vegetables (%)			
No	36/79 (45.6)	1.00	1.00
Yes	71/217 (32.7)	0.58 (0.34–0.99)	0.44 (0.24–0.79)
Fruit (%)			
No	31/112 (27.7)	1.00	1.00
Yes	76/184 (41.3)	1.84 (1.11–3.08)	1.33 (0.75–2.35)
Soy products (%)			
No	34/100 (34.0)	1.00	1.00
Yes	73/296 (37.2)	1.15 (0.70–1.92)	1.03 (0.60–1.79)
Dairy products (%)			
No	31/106 (29.3)	1.00	1.00
Yes	76/190 (40.0)	1.61 (0.98–2.71)	1.63 (0.96–2.82)
Severe nocturia			
Fried foods (%)			
No	27/241 (11.2)	1.00	1.00
Yes	7/55 (12.7)	1.16 (0.44–2.68)	1.35 (0.49–3.33)
Eggs (%)			
No	21/183 (11.5)	1.00	1.00
Yes	13/113 (11.5)	1.00 (0.47–2.07)	1.00 (0.45–2.13)
Fatty meat (%)			
No	25/203 (12.3)	1.00	1.00
Yes	9/93 (9.7)	0.76 (0.32–1.65)	0.77 (0.32–1.74)
Seafood (%)			
No	9/87 (10.3)	1.00	1.00
Yes	25/209 (12.0)	1.18 (0.54–2.77)	0.98 (0.42–2.45)
Pickles (%)			
No	22/201 (11.0)	1.00	1.00
Yes	12/95 (12.6)	1.18 (0.54–2.45)	0.88 (0.39–1.92)
Vegetables (%)			
No	15/79 (19.0)	1.00	1.00
Yes	19/217 (8.8)	0.41 (0.20–0.86)	0.34 (0.15–0.78)
Fruit (%)			
No	7/112 (6.3)	1.00	1.00
Yes	27/184 (14.7)	2.58 (1.14–6.63)	2.20 (0.88–6.11)
Soy products (%)			
No	13/100 (13.0)	1.00	1.00
Yes	21/196 (10.7)	0.80 (0.39–1.72)	0.80 (0.37–1.80)
Dairy products (%)			
No	11/106 (10.4)	1.00	1.00
Yes	23/190 (12.1)	1.19 (0.57–2.64)	1.13 (0.51–2.59)

Odds ratios (OR) were adjusted for age, body mass index, glycated hemoglobin, hypertension, dyslipidemia, current smoking, current drinking, exercise habit, stroke, ischemic artery disease, diabetic nephropathy, diabetic neuropathy and diabetic retinopathy. CI, confidence interval.

LUTS[9]. Dietary isoflavone intake was significantly inversely associated with LUTS in a Chinese study of 2,000 men[7]. Intake of citrus juice was significantly inversely associated with LUTS in a USA study of 4,144 participants[8]. Beer intake was significantly inversely associated with the onset of OAB in a UK study of men[12].

No evidence regarding the association between dietary intake and nocturia exists. Nocturia is a storage symptom. In the general population, citrus juice was significantly inversely associated with storage symptoms in men, but not women; coffee intake was significantly positively associated with storage symptoms only in men, while soda intake was significantly positively associated with storage symptoms only in women[8].

The mechanism linking vegetable intake habit and nocturia is not well understood. Vegetables are high in anti-oxidants, fibers, minerals and vitamins[24]. Vegetable intake might reduce postprandial hyperglycemia[25]. Among patients with diabetes, postprandial hyperglycemia is associated with increasing oxidative stress and inflammation[26,27]. Vegetable intake might beneficially affect the prostate and bladder by inhibiting inflammation and oxidative damage.

The present study had several limitations that must be acknowledged. First, we used a cross-sectional analysis to assess the association between dietary intake habits and nocturia. Second, we used a "yes"/"no" response format partially validated questionnaire to assess dietary intake habits. A previous study using the same "yes"/"no" format questionnaire found that the participants who reported eating something frequently had a higher intake than the other participants[22]. In previous epidemiological studies, the participants with a high vegetable intake were older, and showed a lower prevalence of hypertension and current smoking[28,29]. In the present study, similar characteristics as previous studies were observed among patients with vegetable intake habit. Therefore, we might assess the vegetable intake habit by this questionnaire. A "yes"/"no" response format questionnaire should be used only to assess vegetable intake habits. As consuming vegetables is thought to be a

healthy habit, thus we should consider the possibility of misclassification. However, the possibility of non-differential outcome misclassification might have biased the magnitude of the observed associations toward the null. The questionnaire in the present study was inadequate to evaluate total energy intake, nutrient intake, and the dose–response association between eating vegetables and nocturia. Thus, further research based on a validated food frequency questionnaire is required to confirm the association between intake of vegetables and nocturia. Third, we used a questionnaire to survey nocturia. We could not carry out a urological test for nocturia, nor could we estimate BPH or bladder function. In a previous study, the overestimation of nocturia based on a questionnaire was reported[30]. Among previous epidemiological studies[4–16], however, the definition of nocturia was based on a questionnaire and/or interview. Fourth, many of the patients might have opted to consume vegetables to control their hyperglycemia. Fifth, in a previous study, the intake of salt and water affected nocturia[31,32], but we could not estimate the intake of salt and water in the present study. Nocturia is likely a multifactorial disorder, and we could not rule out residual confounding factors. Finally, we could not control for the patients' socioeconomic status.

In conclusion, we found an inverse association between vegetable intake habits and nocturia in Japanese patients with type 2 diabetes mellitus. Further studies are required to show the beneficial intake of vegetables for nocturia among patients with type 2 diabetes mellitus.

ACKNOWLEDGMENTS

This study was supported by the Japan Society for the Promotion of Science (JSPS) KAKENHI Grants (21790583 and 23790697). We thank Morikazu Onji from Saiseikai Imabari Hospital, Eriko Kawamoto from the University of the Ryukyus, Keiko Kikuchi and Tomo Kogama from Ehime University, and Eri Furukawa from the Furukawa Clinic.

DISCLOSURE

The authors declare no conflict of interest.

REFERENCES

1. Furukawa S, Sakai T, Niiya T, *et al.* Nocturia and prevalence of erectile dysfunction in Japanese patients with type 2 diabetes mellitus. The Dogo Study. *J Diabetes Investig* 2016; 7: 786–790.
2. Furukawa S, Sakai T, Niiya T, *et al.* Microvascular complications and prevalence of nocturia in Japanese patients with type 2 diabetes mellitus: the Dogo Study. *Urology* 2016; 93: 147–151.
3. Furukawa S, Sakai T, Niiya T, *et al.* Nocturia and prevalence of depressive symptoms in Japanese patients with type 2 diabetes mellitus: The Dogo Study. *Can J Diabetes* 2017; https://doi.org/10.1016/j.jcjd.2017.03.002
4. Liu ZM, Wong CK, Chan D, *et al.* Fruit and vegetable intake in relation to lower urinary tract symptoms and erectile dysfunction among southern Chinese elderly men: a 4-year prospective study of Mr OS Hong Kong. *Medicine (Baltimore)* 2016; 95: e2557.
5. Koskimäki J, Hakama M, Huhtala H, *et al.* Association of dietary elements and lower urinary tract symptoms. *Scand J Urol Nephrol* 2000; 34: 46–50.
6. Suzuki S, Platz EA, Kawachi I, *et al.* Intake of energy and macronutrients and the risk of benign prostatic hyperplasia. *Am J Clin Nutr* 2002; 75: 689–697.
7. Wong SY, Lau WW, Leung PC, *et al.* The association between isoflavone and lower urinary tract symptoms in elderly men. *Br J Nutr* 2007; 98: 1237–1242.
8. Maserejian NN, Wager CG, Giovannucci EL, *et al.* Intake of caffeinated, carbonated, or citrus beverage types and development of lower urinary tract symptoms in men and women. *Am J Epidemiol* 2013; 17: 1399–1410.
9. Maserejian NN, Giovannucci EL, McKinlay JB. Dietary macronutrients, cholesterol, and sodium and lower urinary tract symptoms in men. *Eur Urol* 2009; 55: 1179–1189.
10. Dallosso HM, McGrother CW, Matthews RJ, *et al.* The association of diet and other lifestyle factors with overactive bladder and stress incontinence: a longitudinal study in women. *BJU Int* 2003; 92: 69–77.
11. Dallosso HM, McGrother CW, Mattthews RJ, *et al.* Nutrient composition of the diet and the development of overactive bladder: a longitudinal study in women. *Neurourol Urodyn* 2004; 23: 204–210.
12. Dallosso HM, McGrother CW, Mattthews RJ, *et al.* The association of diet and other lifestyle factors with overactive bladder: a longitudinal study in women. *Public Health Nutrition* 2004; 7: 885–891.
13. Kristal AR, Arnold KB, Schenk JM, *et al.* Dietary patterns, supplement use, and the risk of symptomatic benign prostatic hyperplasia: results from the prostate cancer prevention trial. *Am J Epidemiol* 2008; 167: 925–934.
14. Rohrmann S, Giovannucci E, Willett WC, *et al.* Fruit and vegetable consumption, intake of micronutrients, and benign prostatic hyperplasia in US men. *Am J Clin Nurt* 2007; 85: 523–529.
15. Araki H, Watanabe H, Mishina T, *et al.* High-risk group for benign prostatic hypertrophy. *Prostate* 1983; 4: 253–264.
16. Bravi F, Bosetti C, Dal Maso L, *et al.* Food groups and risk of benign prostatic hyperplasia. *Urology* 2006; 67: 73–79.
17. Matsuo S, Imai E, Horio M, *et al.* Collaborators developing the Japanese equation for estimated GFR. Revised equations for estimated GFR from serum creatinine in Japan. *Am J Kidney Dis* 2009; 53: 982–992.
18. Haneda M, Utsunomiya K, Koya D, *et al.* A new classification of diabetic nephropathy 2014: a report from Joint Committee on diabetic nephropathy. *J Diabetes Investig* 2015; 6: 242–246.
19. Fukuda M. Classification and treatment of diabetic retinopathy. *Diabetes Res Clin Pract* 1994; 24: s171–s176.

20. Yasuda H, Sanada M, Kitada K, *et al*. Rationale and usefulness of newly devised abbreviated diagnostic criteria and staging for diabetic polyneuropathy. *Diabetes Res Clin Pract* 2007; 77: S178–S183.
21. Umesawa M, Kitamura A, Kiyama M, *et al*. Association between dietary behavior and risk of hypertension among Japanese male worker. *Hypertens Res* 2013; 36: 374–380.
22. Nishimura S, Miyazaki J, Kuwabara C, *et al*. Conditions and problems of dietary behavior in urban populations (Part 2) relationship between dietary research and dietary behaviors. *Nihon Kosyu Eisei Zasshi* 2006; 57(Suppl): 956. (Japanese)
23. Lagiou P, Wuu J, Trichopoulou A, *et al*. Diet and benign prostatic hyperplasia: a study in Greece. *Urology* 1999; 54: 284–290.
24. Roehrborn CG. Pathology of benign prostatic hyperplasia. *Int J Impo Res* 2008; 126: S11–S18.
25. Imai S, Fukui M, Ozasa N, *et al*. Eating vegetables before carbohydrates improves postprandial glucose excursions. *Diabet Med* 2013; 30: 370–372.
26. Ceriello A, Bortolotti N, Motz E, *et al*. Meal-generated oxidative stress in type 2 diabetic patients. *Diabetes Care* 1998; 21: 1529–1533.
27. Gallwitz B. Implications of postprandial glucose and weight control in people with type 2 diabetes: understanding and implementing the International Diabetes Federation guidelines. *Diabetes Care* 2009; 32(suppl 2): S322–S325.
28. Takachi R, Inoue M, ishihara J, *et al*. Fruit and vegetable intake and risk of total cancer and cardiovascular diseases Japan Public Health Center-based Prospective Study. *Am J Epidemiol* 2008; 167: 59–70.
29. Bazzano LA, He J, Ogden LG, *et al*. Fruit and vegetable intake and risk of cardiovascular disease in US adults: the first national health and nutrition examination survey epidemiologic follow-up study. *Am J Clin Nutr* 2002; 76: 93–99.
30. van Haarst EP, Bosch JL, Heldeweg EA. The international prostate symptom score overestimates nocturia assessed by frequency-volume charts. *J Urol* 2012; 188: 211–215.
31. Matsuo T, Miyata Y, Sasaki H. Daily salt intake is an independent risk factor for pollakiuria and nocturia. *Int J Urol* 2017; 24: 384–389.
32. Soda T, Masui K, Okuno H, *et al*. Effecacy of nondrug lifestyle measures for the treatment of nocturia. *J Urol* 2010; 184: 1000–1004.