

Original article

Nutritional status of calcium and other bone-related nutrients in Japanese type 2 diabetes patients

Eisuke Tomastu^a, Eri Ninomiya^b, Mizuho Ando^a, Izumi Hiratsuka^a, Yasumasa Yoshino^a, Sahoko Sekiguchi-Ueda^a, Megumi Shibata^a, Akemi Ito^b, Kazuhiro Uenishi^c, Atsushi Suzuki^{a,*}

^a Division of Endocrinology and Metabolism, Department of Internal Medicine, Fujita Health University, Toyoake, Aichi, Japan

^b Food and Nutrition Service, Fujita Health University Hospital, Toyoake, Aichi, Japan

^c Laboratory of Physiological Nutrition, Kagawa Nutrition University, Sakado, Saitama, Japan

Received 5 February 2016; revised 18 March 2016; accepted 26 March 2016

Available online 21 April 2016

Abstract

Objectives: Traditional Japanese food appears to be healthy but contains a small amount of milk products. Type 2 diabetes (T2DM) patients commonly reduce their energy intake to control their blood glucose levels. However, nutritional guidance for diabetes does not emphasize calcium (Ca) consumption. The aim of this study is to estimate the nutritional status of Ca and other nutrients, which affect bone and Ca metabolism, in T2DM patients.

Methods: This observational study was conducted with Japanese T2DM patients (n = 96; M/F = 50/46; age: 61.6 ± 10.1 years). We estimated nutrient intake using a simple food frequency questionnaire.

Results: Median total energy intake was 1750 kcal/day (1440–1970). Their median daily intake of Ca, vitamin D, and vitamin K was 451 mg (336–560), 10.2 µg (8.5–12), and 206 µg (84–261), respectively. Only 17.7% of the study subjects were found to take more than 600 mg/day of Ca. Protein and salt intake was 78 (64–90) and 10.6 (9.3–12.2) g/day, respectively. Male subjects had more salt, less Ca and vitamin K than female. Daily Ca intake was positively associated with total energy, protein, and lipid intake but not with carbohydrates. Vitamin D intake correlated only with protein intake.

Conclusions: The daily Ca intake of Japanese T2DM patients appears to be insufficient and could depend on protein and lipid intake. Additionally, these patients should have specific recommendations to ensure sufficient intake of Ca with protein and lipid during energy restriction. © 2016 The Korean Society of Osteoporosis. Publishing services by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Keywords: Vitamin D; Calcium; Diabetes; Nutrition

1. Introduction

Type 2 diabetes (T2DM) is considered to be a worldwide healthcare burden in both developed and developing countries [1]. Because T2DM is highly associated with patients' lifestyle, nutritional intervention should be considered in addition

to medication and exercise [2]. Even in non-obese subjects, visceral fat accumulation can induce systemic arteriosclerosis, and its accumulation is related to eating behavior [3]. Therefore, total energy restriction to reduce body weight in T2DM patients is often encountered during nutrition counseling. Although weight reduction should reduce bone mass, better glycemic control is considered to contribute more to bone health in T2DM patients [4], [5].

Japanese traditional cooking has low lipid content and is considered to be healthier than Western food. However, salt use in Japanese cooking remains high [6], and the calcium content remains low due to less inclusion of milk products.

* Corresponding author. Division of Endocrinology and Metabolism, Department of Internal Medicine, Fujita Health University, 1-98 Dengakugakubo, Kutsukake, Toyoake, Aichi, 470-1192, Japan.

E-mail address: aslapin@fujita-hu.ac.jp (A. Suzuki).

Peer review under responsibility of The Korean Society of Osteoporosis.

According to the annual report from the Japanese Ministry of Health, Labor and Welfare, the mean calcium and sodium intake in the Japanese adult population in 2013 were 498 and 4040 mg/day, respectively. However, the precise amount of calcium and other bone-related nutrients in Japanese T2DM patients under nutritional guidance is unclear.

In the present study, we estimated nutrient intake using a simple food frequency questionnaire in Japanese T2DM patients to accumulate the data for developing optimal nutritional guidance to diabetic patients with osteoporosis.

2. Materials and methods

T2DM (n = 96, M/F = 50/46) patients of Fujita Health University Hospital were recruited for this study (Table 1). The median age of the patients was 61.6 years (52.8–73.0 years, interquartile range). Hypertension was defined as requiring the use of antihypertensive medication or having average measured blood pressure (140/90 mmHg). We defined dyslipidemia when the patients had a high serum level of low-density lipoprotein cholesterol [≥ 120 mg/dL for the patients without prevalent cardiovascular disease (CVD) and ≥ 100 mg/dL for patients with CVD], high level of serum triglycerides (≥ 150 mg/dL), low level of high-density lipoprotein cholesterol (< 40 mg/dL), and users of lipid-lowering medication (i.e., HMG-CoA reductase inhibitors). With these definitions, 46.9% of our patients had hypertension, while 49% had dyslipidemia. Diabetic nephropathy was diagnosed according to the criteria defined by the Japanese Society of Nephrology [7]. The patients included were classified as stage 2 (31.2%), stage 3 (6.3%), and stage 4 (1%). No hemodialysis patients were observed in this study. Retinopathy was diagnosed as simple diabetic retinopathy (12.5%), pre-proliferative diabetic retinopathy (6.3%), and proliferative diabetic retinopathy (11.5%) by ophthalmologists with extensive experience. Patient who had recent fragility fracture within 3 months of the study, were excluded from the study. We noted that none of the respondents to this questionnaire took Ca or vitamin D

supplements. We estimated the intake of total energy consumption (apart from alcohol) for Ca, vitamin D, and other nutrients using a simple food frequency questionnaire prepared by Uenishi et al. [8]. This descriptive study was approved by the Review Board for Epidemiology and Clinical Studies of Fujita Health University (#08-175) (Aichi, Japan). It was therefore undertaken in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. Written informed consent was obtained from each subject.

2.1. Statistical analysis

Data are expressed as the median with an interquartile range. All analyses were performed using the JMP 8.0.1 statistical software (SAS Inc., Cary, NC, USA). The relationship between the intake of nutrients and minerals was examined using a single regression analysis. A value of $P < 0.05$ was considered to be significant.

3. Results

The median total energy intake in T2DM patients was 1750 kcal/day (1440–1970) (Table 2). Protein, lipid, and carbohydrate intake was 78 (64–90), 63 (50–74) and 223 g/day (170–251), respectively. Salt and Fe intake was 10.6 (9.3–12.2) and 6.8 g/day (6.4–9.5), respectively. The daily intake of Ca, as well as vitamins A, D, and K was 451 mg (336–560), 917 μ gRE (537–1171), 10.2 μ g (8.5–12.0), and 206 μ g (84–261), respectively. Only 17.7% of study subjects were found to consume more than 600 mg/day of Ca. Male subjects had more salt, less Ca and vitamin K than female (Table 2). The total energy intake correlated with the protein ($p < 0.001$), lipid ($p < 0.001$), and carbohydrate ($p < 0.001$) intake (Fig. 1). Daily Ca intake was positively associated with the total energy intake ($p = 0.022$) (Fig. 2A). Ca intake was related not to carbohydrate but to protein ($p = 0.016$) and lipid ($p = 0.011$) intake (Fig. 2B–D). Vitamin D intake did not correlate with total energy intake but with protein consumption ($p = 0.037$) (Fig. 3).

4. Discussion

In the present study, we found that the majority of Japanese T2DM patients consumed less Ca than the national estimated average requirement (500–600 mg/day) and the recommended intake (650–700 mg/day) by the Japanese Ministry of Health, Labor and Welfare [9]. T2DM is now considered to be a risk factor for fragility fracture particularly in elderly people, and a higher Ca intake is recommended according to the guidelines of the Japan Osteoporosis Society [10]. Therefore, more attention should be paid to Ca and vitamin D intake in Japanese T2DM patients. Male subjects had less Ca and vitamin K than female, while more salt intake was found in male. This result may reflect that nutritional imbalance is more common in male Japanese diabetes patients than in female patients.

Table 1
Details of study subjects.

Variables	Interquartile range (25th–75th)
Gender (M/F)	50/46
Age (y)	61.6 (52.8–73.0)
Height (cm)	161.4 (155.0–167.9)
Weight (kg)	66.7 (54.5–76.4)
BMI (kg/m ²)	25.3 (21.6–29.0)
HbA1c (%)	9.4 (7.2–10.6)
Hypertension	45/96
Dyslipidemia	47/96
Nephropathy	30/96
	Stage 2
	Stage 3
	Stage 4
Retinopathy	12/96
	SDR
	PPDR
	PDR

BMI, body mass index; SDR, simple diabetic retinopathy; PPDR, pre-proliferative diabetic retinopathy; PDR, proliferative diabetic retinopathy.

Table 2
Daily intake of total energy and each nutrient according to simple food frequency questionnaire.

	All interquartile range (25th–75th)	Male interquartile range (25th–75th)	Female interquartile range (25th–75th)	p ^a
Total Energy (Cal/d)	1750 (1440–1970)	1794 (1464–2003)	1714 (1354–1902)	0.25
Protein (g/d)	78.0 (63.6–89.6)	77.1 (68.0–88.6)	76.5 (62.9–89.6)	0.69
Lipid (g/d)	62.6 (50.4–73.5)	62.1 (52.6–75.2)	63.9 (49.4–72.8)	0.99
Carbohydrate (g/d)	223 (170–251)	224 (182–253)	211 (151–246)	0.19
NaCl (g/d)	10.6 (9.3–12.2)	10.8 (10.0–12.4)	10.2 (8.7–11.5)	0.03
Ca (mg/d)	451 (336–560)	413 (309–520)	489 (363–652)	0.03
Fe (mg/d)	6.8 (6.4–9.5)	7.9 (6.8–9.4)	7.7 (6.0–10.1)	0.97
Vitamin A (mgRE/d)	917 (537–1171)	729 (524–1142)	761 (600–1233)	0.42
Vitamin D (μg/d)	10.2 (8.5–12.0)	10.0 (8.0–12.0)	10.5 (8.5–12.0)	0.20
Vitamin K (μg/d)	206 (84–261)	156 (70–247)	211 (126–268)	0.03

^a Difference between male and female was analyzed by Mann–Whitney's U test.

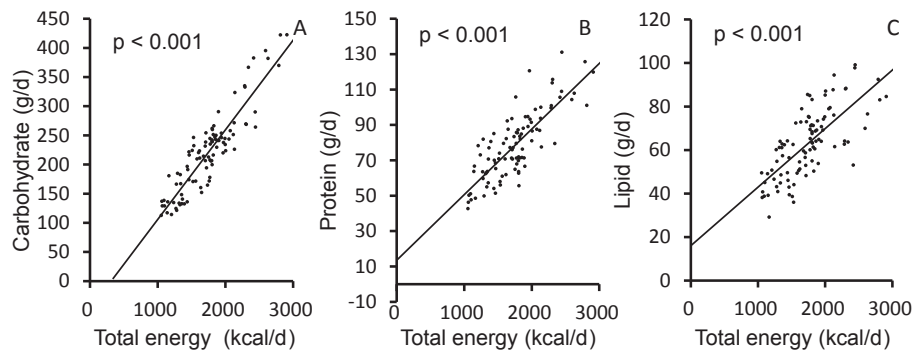


Fig. 1. The relationship between total energy and carbohydrate (A), protein (B), and lipid intake (C) in Japanese type 2 diabetes patients.

The Japan Diabetes Society [11] and other scientific societies such as American Diabetes Association [2] recommend energy restriction to improve the metabolic status of obese T2DM patients. In this study, we found that the daily Ca intake did not depend on carbohydrate but on protein and lipid intake. Therefore, to maintain enough Ca intake during energy

restriction, it might be beneficial to reduce carbohydrates but not lipids or protein. Furthermore, only protein intake among the three major nutrients contributed to vitamin D intake. However, diabetes patients with overt nephropathy are recommended to take less protein in order not to accelerate renal dysfunction. Renal impairment is also associated with less

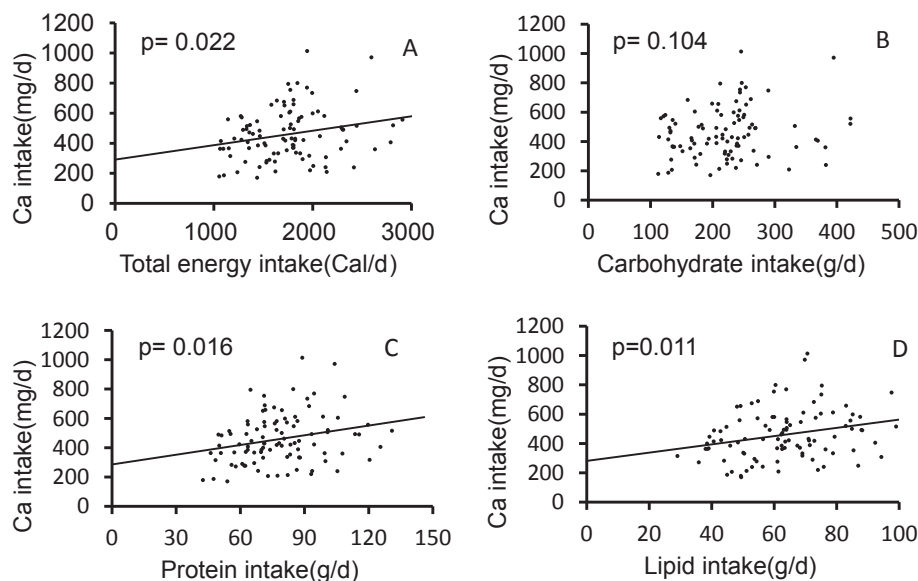


Fig. 2. The relationship between Ca intake and total energy (A), carbohydrate (B), protein (C), and lipid intake (D) in Japanese type 2 diabetes patients.

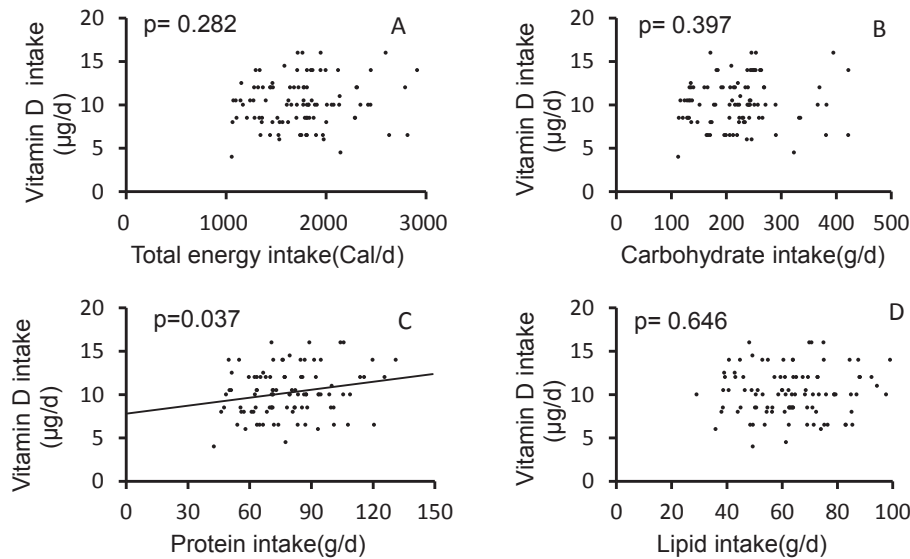


Fig. 3. The relationship between vitamin D intake and total energy (A), carbohydrate (B), protein (C), and lipid intake (D) in Japanese type 2 diabetes patients.

activation of vitamin D, which then reduces Ca absorption from intestine. Therefore, we should pay more attention to keep enough amount of Ca and vitamin D in diabetes patients with nephropathy. The primary source of vitamin D in Japanese individuals is via fish consumption [12]. Fish oil is also recommended for preventing atherosclerosis in adults, and protein intake from fish might also be suitable for Japanese T2DM patients with osteoporosis. However, Japanese way of cooking fish often includes a high amount of salt as seasoning [13]. High sodium intake could increase urinary Ca excretion, which can result in negative Ca balance. Furthermore, salt sensitivity in essential hypertension is associated with both endothelial dysfunction and increased cardiovascular risk [14], [15]. Because patients with diabetes often have atherosclerosis and high cardiovascular risks, the reduction of salt intake should be recommended when an increase in fish consumption is suggested to them.

There are several limitations to this study. First, we assessed the nutrient intake using a self-monitored questionnaire. Second, this study was performed with relatively small number of subjects in a single center. Third, we did not perform correlation of the nutritional data collected with bone assessments such as bone mineral density and bone turnover markers. Fourth, this study is cross-sectional and requires further research to prove the benefit of nutritional guidance with additional Ca and less salt to diabetes patients with osteoporosis.

In conclusion, our study suggests that the daily Ca intake of Japanese T2DM patients appears to be insufficient and depends on protein and lipid intake. Additionally, these patients should have specific recommendations to ensure sufficient intake of Ca with protein and lipid during energy restriction.

Conflicts of interest

No potential conflicts of interest were disclosed.

Acknowledgments

We are indebted to Emiko Horii for her technical assistance.

References

- [1] Whiting DR, Guariguata L, Weil C, Shaw J. IDF Diabetes Atlas: global estimates of the prevalence of diabetes for 2011 and 2030. *Diabetes Res Clin Pract* 2011;94:311–21.
- [2] American Diabetes Association 3. Foundations of care and comprehensive medical evaluation. *Diabetes Care* 2016;39(Suppl 1):S23–35.
- [3] Fukuda S, Hirata A, Nishizawa H, Nagao H, Kashine S, Kimura T, et al. Systemic arteriosclerosis and eating behavior in Japanese type 2 diabetic patients with visceral fat accumulation. *Cardiovasc Diabetol* 2015;14:1–8.
- [4] Baum T, Yap SP, Karampinos DC, Nardo L, Kuo D, Burghardt AJ, et al. Does vertebral bone marrow fat content correlate with abdominal adipose tissue, lumbar spine bone mineral density, and blood biomarkers in women with type 2 diabetes mellitus? *J Magn Reson Imaging* 2012;35:117–24.
- [5] Epstein S, LeRoith D. Diabetes and fragility fractures – a burgeoning epidemic? *Bone* 2008;43:3–6.
- [6] Takase H, Sugiura T, Kimura G, Ohte N, Dohi Y. Dietary sodium consumption predicts future blood pressure and incident hypertension in the Japanese normotensive general population. *J Am Heart Assoc* 2015;4:e001959.
- [7] Haneda M, Utsunomiya K, Koya D, Babazono T, Moriya T, Makino H, et al. A new classification of diabetic nephropathy 2014: a report from joint committee on diabetic nephropathy. *J Diabetes Investig* 2015;6:242–6.
- [8] Uenishi K, Ishida H, Nakamura K. Development of a simple food frequency questionnaire to estimate intakes of calcium and other nutrients for the prevention and management of osteoporosis. *J Nutr Sci Vitaminol (Tokyo)* 2008;54:25–9.
- [9] The Japanese Ministry of Health Labor and Welfare. *Overy Diet Reference Intakes Jpn* 2015;21:1–42.
- [10] Orimo H, Nakamura T, Hosoi T, Iki M, Uenishi K, Endo N, et al. Japanese 2011 guidelines for prevention and treatment of osteoporosis-executive summary. *Arch Osteoporos* 2012;7:3–20.
- [11] Japan Diabetes Society. *Treatment guide for diabetes 2012–2013*. Tokyo: Bunkodo; 2013. p. 1–50.

- [12] Calvo MS, Whiting SJ, Barton CN. Symposium: vitamin D insufficiency: a significant risk factor in chronic diseases and potential disease-specific biomarkers of vitamin D sufficiency vitamin D intake: a global perspective of current status 1. *J Nutr* 2005;25:310–6.
- [13] Anderson CAM, Appel LJ, Okuda N, Brown IJ, Chan Q, Zhao L, et al. Dietary sources of sodium in China, Japan, the United Kingdom, and the United States, women and men aged 40 to 59 years: the INTERMAP study. *J Am Diet Assoc* 2010;110:736–45.
- [14] Takachi R, Inoue M, Shimazu T, Sasazuki S, Ishihara J, Sawada N, et al. Consumption of sodium and salted foods in relation to cancer and cardiovascular disease: the Japan Public Health Center-based prospective study. *Am J Clin Nutr* 2010;91:456–64.
- [15] Bragulat E, de la Sierra A. Salt intake, endothelial dysfunction, and salt-sensitive hypertension. *J Clin Hypertens* 2002;4:41–6.