Original Article

Overall nutrient and total fat intake among Japanese people: The INTERLIPID Study Japan

Tatsuya Koyama RD[1], Katsushi Yoshita RD, PhD[1], Nagako Okuda MD, PhD[2], Shigeyuki Saitoh MD, PhD[3], Kiyomi Sakata MD, PhD[4], Akira Okayama MD, PhD[5], Hideaki Nakagawa MD, PhD[6], Naoko Miyagawa RD, PhD[7], Katsuyuki Miura MD, PhD[7,8], Queenie Chan MD, PhD[9], Paul Elliott MD, PhD[9], Jeremiah Stamler MD, PhD[10], Hirotsugu Ueshima MD, PhD[8]

[1]Department of Food and Human Health Science, Graduate School of Human Life Science, Osaka City University, Osaka, Japan
[2]Department of Health and Nutrition, Faculty of Human Science, University of Human Arts and Sciences, Saitama, Japan
[3]Division of Medical and Behavioral Subjects, Sapporo Medical University School of Health Science, Sapporo, Japan
[4]Department of Hygiene and Preventive Medicine, Iwate Medical University, Iwate, Japan
[5]Research Institute of Strategy for Prevention, Tokyo, Japan
[6]Kanazawa Medical University Medical Research Institute, Ishikawa, Japan
[7]Department of Health Science, Shiga University of Medical Science, Shiga, Japan
[8]Center for Epidemiologic Research in Asia, Shiga University of Medical Science, Shiga, Japan
[9]Department of Epidemiology and Biostatistics, School of Public Health, Faculty of Medicine, Imperial College London, London, UK
[10]Department of Preventive Medicine, Feinberg School of Medicine, Northwestern University, Chicago, USA

Background and Objectives: Total fat intake is linked to the intake of other nutrients. Little data are available on the extent to which total fat affects diet quality in Japanese people. We investigated the relationship between total fat intake and other nutrient intake using INTERLIPID/ INTERMAP data on Japanese people living in Japan. **Methods and Study Design:** The participants included 371 men and 401 women with a healthy body mass index and between the ages of 40 and 59 from 4 population samples in Japan. Nutrient intake data were based on four in-depth 24-hour dietary recalls per person. **Results:** Analysis of covariance adjusted for age revealed that total fat intake was positively related to intakes of calcium, thiamine, riboflavin, meat, eggs, and milks and dairy products for both sexes. Total fat intake was inversely associated with carbohydrate and cereals intake for both sexes. On average, men with total fat intake between 25.0 and 27.4% of total energy had saturated fatty acids above 7%, which is the upper limit recommended for preventing lifestyle-related diseases. Men with total fat intake less than 20% of total energy had a higher risk of not meeting the Dietary Reference Intakes for Japanese (2015) for some nutrients. **Conclusions:** Total fat intake was positively associated with calcium, thiamine, and riboflavin intakes and inversely associated with carbohydrate intake. Our results suggest that in 40–59-year-old men with a healthy body mass index, total fat intake between 20 and 27% of total energy may best support adequate intake of other nutrients.

Key Words: total fat intake, nutrient intake, diet quality, food group intake, Dietary Reference Intakes for Japanese

INTRODUCTION

Dietary fat is an important source of energy. It facilitates the absorption of fat-soluble vitamins and provides essential fatty acids.[1-3] Fat enhances taste and acceptability of foods, and lipid components largely determine the texture, flavor, and aroma of foods.[1]

Most organizations recommend that adult consume a total fat intake that is 20–35% of total energy.[1,2] The Dietary Reference Intakes for Japanese (2015) (DRIs) took into consideration data from Western countries and set

Corresponding Author: Tatsuya Koyama, Department of Food and Human Health Science, Graduate School of Human Life Science, Osaka City University, 3-3-138 Sugimoto Sumiyoshi-ku, Osaka 558-8585, Japan.
Tel: +81-6-6605-2867; Fax: +81-6-6605-2909
Email: koyama0139@gmail.com; tkoyama@mukogawa-u.ac.jp
Manuscript received 14 September 2015. Initial review completed 25 April 2016. Revision accepted 10 May 2016.
doi: 10.6133/apjcn.072016.11

the upper boundary of total fat intake at 30% of total energy.[3] In most Asian countries including Japan, total fat intake is lower than that in Western countries.[4] For example, between 1997 and 1999, which is when the INTERLIPID survey was conducted, the mean total fat intake in Japanese men and women was 25% of total energy, while total fat intake contributed an average of 33% of total energy for men and women in the United Kingdom and the United States.[5] Owing to different dietary patterns, data about total fat intake in Japanese populations are necessary to determine the appropriate upper limit of total fat intake for Japanese people.

Total fat intake affects the intake of other nutrients. However, evidence for this remains limited within the Japanese population.[4] We surmised that if a nutritional deficiency existed concurrent with a specific level of total fat intake, investigations regarding the relationship between total fat intake and other nutrient intake would be informative. Using INTERLIPID/ INTERMAP data collected from 1997 to 1999,[6-8] we assessed the relationships between total fat intake and various other nutrient intakes. We analyzed data from Japanese population samples in the INTERLIPID Study, an ancillary study of the population-based INTERMAP investigation. INTERMAP was a highly standardized, international population-based cooperative study of macro and micronutrient intakes and blood pressure in individuals whose food and nutrient intake was assessed by four in-depth 24-hour dietary recalls and two 24-hour urine collections.

MATERIALS AND METHODS

Participants

The participants included Japanese living in Japan who participated in the INTERLIPID Study, an INTERMAP ancillary study.[6-8] The detailed methods of these two studies are summarized below. A series of four in-depth 24-hour dietary recalls were obtained. In addition, non-fasting blood samples were drawn from all participants. Four research centers recruited random samples of Japanese men and women aged 40–59 years old. The study protocol was approved by the ethics committees of Sapporo Medical University, Kanazawa Medical University, Shiga University of Medical Science, Wakayama Medical University, and Northwestern University. Our study was performed in accordance with the ethical standards laid down in the Declaration of Helsinki. Written informed consent was obtained from all participants.

Body mass index (BMI) is a tool that may be used to assess adequacy of energy intake within a population.[3] BMI is calculated as weight divided by height squared (kg/m^2). It may be assumed that those with a BMI within the healthy range (18.5–24.9 kg/m^2 for 40–49-year-old participants and 20.0–24.9 kg/m^2 for 50–59-year-old participants) are consuming adequate energy.[3] Of the 1145 individuals initially surveyed, we excluded individuals with a BMI outside of the healthy range (n=373), resulting in a study population of 772 (371 men and 401 women).

Anthropometric assessment and blood examination

Participants visited the research centers four times over two sets of consecutive days. These visit sets took place on average 3 weeks apart. Height and weight while wearing light clothing were measured at each visit, and the four height and weight measurements were averaged.

Non-fasting blood samples were drawn on the second day of the first two-day visit set. The time of last meal was recorded. Serum and plasma samples were obtained via centrifugation within 30 minutes of blood drawing; specimens were immediately refrigerated. Within 24 hours, all specimens were frozen and stored locally at -70°C. The central laboratory was standardized by the Lipid Standardization Program (Centers for Disease Control and Prevention, Atlanta, GA, USA); it successfully met the criteria of precision and accuracy of control.[9] The laboratory is currently a member of the Cholesterol Reference Method Laboratory Network.[10] Serum concentrations of total cholesterol, high-density lipoprotein cholesterol (HDL-c), low-density lipoprotein cholesterol (LDL-c), and non-fasting triglycerides (TG) were directly measured by enzymatic methods using an auto-analyzer (Hitachi 7107; Hitachi, Tokyo, Japan).

Dietary assessment

Four 24-hour dietary recalls per participant were conducted during each of the four visits by specially trained dietary interviewers. Standardized quality control procedures were used to assess and maximize the quality of all dietary data. Nutrient intakes of participants were calculated based on a special food table from the INTERMAP Japan study. This food table was developed based on the Standard Table of Food Composition in Japan (fourth edition),[11] taking into consideration changes in weight and nutrient content due to cooking and/or processing.[7,12] Food groups were classified according to the Standard Tables of Food Composition in Japan (fourth edition).[11]

For this study, energy including and excluding alcohol was used to calculate nutrient density. Energy derived from alcohol was calculated as alcohol intake (g/day) × 7 kcal/g, and energy excluding from alcohol (i.e., only energy from food: total protein, total fat, and available carbohydrate) was calculated as total energy minus energy derived from alcohol. Energy densities for protein, total fat, saturated fatty acids, and available carbohydrate were calculated using energy including or excluding alcohol.

We selected nutrients based on priorities recommended in the DRIs (2010), which include protein, available carbohydrates, alcohol, dietary fiber, sodium, potassium, calcium, iron, vitamin A, thiamine, riboflavin, and vitamin C.[13] We also examined dietary fat quality, including fatty acids (saturated fatty acids, and n-6 and n-3 polyunsaturated fatty acids), cholesterol, and Keys dietary score. The Keys dietary lipid score, which is predictive of serum total cholesterol, was calculated as $1.35 \times (2SFA - PUFA) + 1.5 \times C^{1/2}$, where SFA is % of total energy from saturated fatty acids; PUFA, % of total energy from polyunsaturated fatty acids; C dietary cholesterol in mg/1000 kcal.[14]

Comparison with Dietary Reference Intakes for Japanese 2015

Nutrient intakes of participants were compared with the DRIs (2015).[3] For saturated fatty acids and sodium, intakes values less than the tentative dietary goal for preventing life-style related diseases (DG) were considered as meeting the DRIs (2015). For dietary fiber, intake more than the DG was considered as meeting the DRIs (2015). For n-6 and n-3 polyunsaturated fatty acids and potassium, intakes more than the adequate intake (AI) values were considered as meeting the DRIs (2015). For calcium, iron, vitamin A, thiamine, riboflavin, and vitamin C, intake values higher than the recommended dietary allowance (RDA) were considered as meeting the DRIs (2015). Similarly, the estimated average requirement (EAR) was also used to evaluate intakes of these 6 nutrients.

Previously, the 2010 DRIs recommended that cholesterol intake be limited to no more than 750 mg/day for men and 600 mg/day for women.[15] The 2015 DRIs does not support this recommendation, because available evidence shows no appreciable relationship between consumption of dietary cholesterol and serum cholesterol.[3]

Calculation of nutrient score

To evaluate nutrients at the individual level, we created two nutrient scores: the Recommended Daily Allowance nutrient score (DG/AI/RDA) and the Estimated Average Requirement nutrient score (DG/AI/EAR). The 12 nutrients we used to evaluate nutrient scores, i.e., saturated fatty acids, n-6 and n-3 polyunsaturated fatty acids, dietary fiber, sodium, potassium, calcium, iron, vitamin A, thiamine, riboflavin, and vitamin C, were selected based on the priorities recommended in the DRIs (2010),[13] as well as dietary fat quality. For each nutrient, participants whose consumption did not meet the DRIs (2015) were assigned a value of 0, and individuals whose consumption met the DRIs (2015) were assigned a value of 1, where RDA was set as the criteria for meeting the DRIs (2015) for calcium, iron, vitamin A, thiamine, riboflavin, and vitamin C. The total of these twelve scores were defined as the Recommended Daily Allowance nutrient score (DG/AI/RDA). Similarly, the Estimated Average Requirement nutrient score (DG/AI/EAR) was calculated using the cutoff points for DG, AI or EAR (instead of DG, AI or RDA). These scores are ranged from 0 (for poor quality diets) to 12 (for high quality diets).

Statistical analyses

We divided total fat intake into the following 6 groups: <20.0%, 20.0–22.4%, 22.5–24.9%, 25.0–27.4%, 27.5–29.9%, and ≥30.0%. For descriptive purposes, means and standard errors were calculated. Analysis of covariance was used in trend analyses of continuously distributed covariates (anthropometric measurements, serum cholesterol, and dietary intakes); adjustments were made for the confounding effects of age. The Mantel-Haenszel test was used to identify trends in prevalence of meeting the DRIs (2015) by total fat intake. We stratified analyses of the prevalence of meeting the DRIs (2015) by two age groups (40–49-years-old and 50–59-years-old), and we observed similar results compared to the unstratified analyses (data not shown). Therefore, we showed only data not stratified by age groups.

All statistical analyses were performed using SPSS for Windows version 20 (IBM Corporation, Tokyo, Japan). All p-values were two-tailed; p-values <0.05 were considered significant.

RESULTS

As shown in Table 1, total fat intake (% energy including alcohol) declined with age. For men total fat intake was positively associated with weight and BMI. For women total fat intake was positively associated with height and weight, while there was no significant association with BMI. Total fat intake was positively associated with HDL-c levels in women.

Table 2 shows the nutrient intakes for the six groups of total fat (% energy including alcohol). In men, total fat

Table 1. Characteristics of Japanese participants by sex and total fat intake (as % energy including alcohol). Participants included 371 men and 401 women with healthy BMI between 40-59 years of age (1997-1999).

	Total fat intake (%energy including alcohol)						Trend p
	<20.0%	20.0-22.4%	22.5-24.9%	25.0-27.4%	27.5-29.9%	≥30.0%	
				Men			
Number of participants	87	68	71	69	41	35	
Age (years)	50.8 (0.6)	48.9 (0.7)	48.2 (0.6)	49.5 (0.6)	48.8 (0.8)	47.7 (0.7)	0.021
Height (cm)	168 (0.6)	168 (0.7)	168 (0.7)	167 (0.7)	169 (0.9)	169 (1.0)	0.341
Weight (kg)	62.7 (0.7)	63.5 (0.7)	63.9 (0.7)	63.5 (0.7)	65.0 (0.9)	65.5 (1.0)	0.013
BMI (kg/m^2)	22.3 (0.2)	22.6 (0.2)	22.6 (0.2)	22.7 (0.2)	22.8 (0.2)	23.0 (0.3)	0.016
Total cholesterol (mg/dL)	200 (3.0)	194 (3.4)	193 (3.3)	203 (3.3)	185 (4.4)	199 (4.7)	0.411
HDL cholesterol (mg/dL)	54.6 (1.5)	55.3 (1.7)	54.0 (1.6)	58.4 (1.7)	53.2 (2.2)	56.1 (2.3)	0.721
LDL cholesterol (mg/dL)	122 (3.1)	116 (3.4)	116 (3.4)	122 (3.4)	111.0 (4.5)	120 (4.8)	0.596
Nonfasting TG (mg/dL)	153 (93.2)	135 (77.3)	169 (119.6)	132 (110.4)	114.0 (53.0)	141 (80.7)	0.157
				Women			
Number of participants	48	37	68	96	59	93	
Age (years)	52.4 (0.7)	49.9 (0.9)	48.1 (0.6)	49.2 (0.5)	48.6 (0.7)	47.4 (0.5)	<0.001
Height (cm)	154 (0.8)	153 (0.9)	156 (0.6)	154 (0.5)	156 (0.7)	156 (0.5)	0.004
Weight (kg)	52.1 (0.8)	51.7 (0.8)	54.1 (0.6)	53.3 (0.5)	53.6 (0.7)	53.6 (0.5)	0.034
BMI (kg/m^2)	22.0 (0.2)	22.2 (0.2)	22.3 (0.2)	22.5 (0.2)	22.0 (0.2)	22.1 (0.2)	0.866
Total cholesterol (mg/dL)	195 (4.4)	195 (4.8)	199 (3.6)	200 (3.0)	198 (3.8)	206 (3.1)	0.051
HDL cholesterol (mg/dL)	58.4 (2.0)	58.2 (2.2)	59.2 (1.6)	62.0 (1.4)	61.6 (1.8)	62.8 (1.4)	0.023
LDL cholesterol (mg/dL)	115 (4.3)	118 (4.8)	121 (3.5)	122 (3.0)	121 (3.8)	124 (3.1)	0.090
Nonfasting TG (mg/dL)	117 (61.4)	99.6 (43.3)	109 (47.9)	98.0 (51.4)	97.6 (67.4)	105 (57.9)	0.198

Values are expressed as the means (standard errors) and are adjusted for age.

Table 2. Daily nutrient intake and total fat intake (as % energy including alcohol). Participants included 371 men and 401 women with healthy BMI between 40--59 years of age (1997-1999).

	Total fat intake (% energy including alcohol)						
	<20.0%	20.0-22.4%	22.5-24.9%	25.0-27.4%	27.5-29.9%	≥30.0%	Trend *p*
Men							
Number of participants	87	68	71	69	41	35	
Nutrient score (RDA/AI/DG)	4.9 (0.2)	5.8 (0.3)	6.1 (0.3)	6.3 (0.3)	6.3 (0.3)	6.3 (0.4)	0.001
Nutrient score (EAR/AI/DG)	6.1 (0.2)	6.8 (0.2)	7.4 (0.2)	7.3 (0.2)	7.4 (0.3)	7.6 (0.3)	<0.001
Energy (kcal)	2222 (45)	2252 (51)	2286 (50)	2297 (50)	2273 (65)	2274 (71)	0.497
No alcohol energy (kcal)	1983 (42)	2034 (47)	2086 (47)	2113 (47)	2156 (61)	2185 (66)	0.003
Protein (g)	82.4 (2.0)	85.4 (2.2)	88.7 (2.2)	90.2 (2.2)	89.4 (2.8)	92.0 (3.1)	0.004
Protein (%E)	14.9 (0.2)	15.3 (0.3)	15.6 (0.3)	15.8 (0.3)	15.7 (0.3)	16.4 (0.4)	<0.001
Total fat (g)	42.5 (1.3)	54.0 (1.5)	60.7 (1.4)	67.3 (1.5)	73.3 (1.9)	81.8 (2.1)	<0.001
Total fat (%E)	17.2 (0.1)	21.3 (0.2)	23.7 (0.2)	26.1 (0.2)	28.6 (0.2)	31.9 (0.2)	<0.001
SFA (g)	11.0 (0.4)	13.6 (0.5)	15.4 (0.5)	18.1 (0.5)	19.1 (0.6)	21.7 (0.7)	<0.001
SFA (%E)	4.5 (0.1)	5.4 (0.1)	6.0 (0.1)	7.0 (0.1)	7.4 (0.2)	8.5 (0.2)	<0.001
N-6 PUFA (g)	8.7 (0.4)	11.1 (0.4)	12.7 (0.4)	13.0 (0.4)	14.7 (0.5)	16.3 (0.6)	<0.001
N-3 PUFA (g)	2.5 (0.1)	3.0 (0.1)	3.4 (0.1)	3.6 (0.1)	3.7 (0.2)	4.3 (0.2)	<0.001
Cholesterol (mg)	366 (19)	436 (21)	443 (21)	482 (21)	487 (27)	485 (29)	<0.001
Keys dietary lipid score	24.8 (0.6)	27.5 (0.6)	28.5 (0.6)	31.4 (0.6)	31.8 (0.8)	33.7 (0.9)	<0.001
Carbohydrates (g)	317 (7.1)	301 (8.0)	296 (7.8)	286 (7.9)	285 (10.3)	270 (11.1)	<0.001
Carbohydrates (%E)	57.2 (0.8)	54.1 (0.9)	51.9 (0.8)	50.4 (0.9)	50.7 (1.1)	48.2 (1.2)	<0.001
Alcohol (g)	34.2 (2.5)	31.1 (2.8)	28.7 (2.8)	26.3 (2.8)	16.8 (3.6)	12.7 (3.9)	<0.001
Alcohol (%E)	10.6 (0.7)	9.2 (0.8)	8.7 (0.8)	7.6 (0.8)	4.9 (1.0)	3.4 (1.1)	<0.001
Dietary fiber (g)	14.8 (0.5)	15.3 (0.6)	15.6 (0.6)	15.0 (0.6)	15.8 (0.7)	16.1 (0.8)	0.187
Sodium (mg)	4902 (132)	5011 (147)	5153 (145)	5032 (146)	4952 (190)	4987 (206)	0.930
Potassium (mg)	2709 (75)	2802 (84)	2889 (82)	2919 (83)	2986 (108)	2971 (117)	0.022
Calcium (mg)	542 (23)	546 (26)	593 (26)	650 (26)	655 (34)	680 (37)	<0.001
Iron (mg)	10.4 (0.3)	10.9 (0.3)	11.4 (0.3)	11.5 (0.3)	12.0 (0.4)	11.9 (0.5)	0.001
Vitamin A (μgRAE)	839 (90)	888 (100)	762 (98)	976 (100)	897 (129)	949 (140)	0.419
Thiamine (mg)	0.88 (0.03)	0.93 (0.03)	0.98 (0.03)	1.03 (0.03)	1.03 (0.04)	1.06 (0.05)	<0.001
Riboflavin (mg)	1.35 (0.04)	1.41 (0.05)	1.47 (0.05)	1.60 (0.05)	1.55 (0.06)	1.61 (0.07)	<0.001
Vitamin C (mg)	115 (8)	127 (9)	121 (9)	125 (9)	143 (12)	118 (13)	0.475

%E: percent energy including alcohol; RAE: retinol activity equivalent.
Values are adjusted by age and means (standard errors).

Table 2. Daily nutrient intake and total fat intake (as % energy including alcohol). Participants included 371 men and 401 women with healthy BMI between 40--59 years of age (1997-1999) (cont.).

	Total fat intake (% energy including alcohol)						Trend *p*
	<20.0%	20.0-22.4%	22.5-24.9%	25.0-27.4%	27.5-29.9%	≥30.0%	
Women							
Number of participants	48	37	68	96	59	93	
Nutrient score (RDA/AI/DG)	6.4 (0.3)	6.7 (0.3)	6.9 (0.3)	7.0 (0.2)	6.6 (0.3)	6.7 (0.2)	0.629
Nutrient score (EAR/AI/DG)	7.4 (0.3)	7.9 (0.3)	7.8 (0.2)	8.2 (0.2)	7.8 (0.2)	7.9 (0.2)	0.339
Energy (kcal)	1771 (47)	1765 (52)	1747 (38)	1765 (32)	1811 (41)	1867 (33)	0.078
No alcohol energy (kcal)	1740 (47)	1734 (52)	1718 (38)	1741 (32)	1787 (41)	1836 (33)	0.065
Protein (g)	66.7 (2.3)	69.5 (2.5)	71.4 (1.9)	70.6 (1.6)	71.6 (2.0)	75.3 (1.6)	0.006
Protein (%E)	15.1 (0.3)	15.9 (0.4)	16.4 (0.3)	16.1 (0.2)	15.9 (0.3)	16.2 (0.2)	0.036
Total fat (g)	35.8 (1.5)	42.5 (1.7)	46.7 (1.2)	52.0 (1.0)	57.8 (1.3)	68.6 (1.1)	<0.001
Total fat (%E)	17.8 (0.2)	21.3 (0.2)	23.8 (0.2)	26.2 (0.2)	28.5 (0.2)	32.9 (0.2)	<0.001
SFA (g)	8.8 (0.5)	11.2 (0.6)	12.4 (0.4)	14.3 (0.4)	15.7 (0.5)	19.2 (0.4)	<0.001
SFA (%E)	4.4 (0.2)	5.6 (0.2)	6.4 (0.1)	7.2 (0.1)	7.7 (0.1)	9.1 (0.1)	<0.001
N-6 PUFA (g)	7.8 (0.4)	9.0 (0.5)	9.3 (0.3)	10.3 (0.3)	11.6 (0.4)	13.1 (0.3)	<0.001
N-3 PUFA (g)	2.1 (0.1)	2.4 (0.1)	2.6 (0.1)	2.6 (0.1)	2.9 (0.1)	3.1 (0.1)	<0.001
Cholesterol (mg)	288 (19)	319 (22)	349 (16)	352 (13)	345 (17)	418 (14)	<0.001
Keys dietary lipid score	23.9 (0.8)	27.4 (0.9)	29.8 (0.6)	31.7 (0.5)	31.5 (0.7)	36.3 (0.6)	<0.001
Carbohydrates (g)	287 (7.2)	268 (8.0)	253 (5.9)	248 (4.9)	245 (6.3)	229 (5.1)	<0.001
Carbohydrates (%E)	65.3 (0.6)	61.0 (0.7)	58.1 (0.5)	56.4 (0.4)	54.3 (0.5)	49.3 (0.4)	<0.001
Alcohol (g)	4.4 (1.2)	4.4 (1.3)	4.1 (1.0)	3.4 (0.8)	3.4 (1.1)	4.4 (0.9)	0.674
Alcohol (%E)	1.7 (0.5)	1.8 (0.5)	1.6 (0.4)	1.3 (0.3)	1.2 (0.4)	1.5 (0.3)	0.407
Dietary fiber (g)	16.8 (0.7)	16.8 (0.8)	15.3 (0.6)	15.9 (0.5)	15.4 (0.6)	15.0 (0.5)	0.017
Sodium (mg)	4246 (161)	4250 (178)	4259 (132)	4175 (111)	4152 (141)	4122 (114)	0.418
Potassium (mg)	2526 (99)	2696 (110)	2639 (81)	2666 (68)	2671 (87)	2732 (70)	0.198
Calcium (mg)	522 (33)	563 (36)	602 (27)	616 (22)	608 (29)	659 (23)	0.001
Iron (mg)	9.1 (0.4)	10.0 (0.4)	9.8 (0.3)	10.0 (0.3)	9.8 (0.3)	10.0 (0.3)	0.130
Vitamin A (µgRAE)	729 (78)	754 (86)	795 (64)	867 (53)	868 (68)	900 (55)	0.033
Thiamine (mg)	0.80 (0.0)	0.82 (0.0)	0.83 (0.0)	0.86 (0.0)	0.86 (0.0)	0.92 (0.0)	0.002
Riboflavin (mg)	1.07 (0.1)	1.16 (0.1)	1.27 (0.0)	1.30 (0.0)	1.31 (0.0)	1.45 (0.0)	<0.001
Vitamin C (mg)	135 (11)	140 (12)	125 (9)	130 (7)	130 (9)	135 (8)	0.764

%E: percent energy including alcohol; RAE: retinol activity equivalent.
Values are adjusted by age and means (standard errors).

intake was positively associated with the DG/AI/RDA nutrient score and the DG/AI/EAR nutrient score, as well as the intake values of non–alcohol energy, protein, potassium, calcium, iron, thiamine, and riboflavin. Total fat intake was inversely associated with carbohydrates and alcohol. The mean difference of the DG/AI/RDA nutrient score between the groups with the highest and lowest total fat intake was 1.4 points. For the DG/AI/EAR nutrient score, the mean difference was 1.5 points. Compared with the <20.0% of total energy group, both types of age-adjusted nutrient scores were significantly higher compared to the other five groups of total fat intake (p<0.05; data not shown). In women, our analyses showed no significant trends for either nutrient score; however, total fat intake was positively associated with protein, calcium, vitamin A, thiamin, and riboflavin intakes and was inversely associated with carbohydrate and dietary fiber intakes. For both sexes, the means of all dietary lipid variables were significantly higher in individuals with higher total fat intake.

The nutritional variables of participants according to the six group of total fat (% energy excluding alcohol) are shown in Appendix. In men, total fat intake was positively associated with both types of the nutrient scores, as well as intakes of total energy, protein, potassium, calcium, iron, thiamine, and riboflavin. The mean difference of the DG/AI/RDA nutrient score between the groups with the highest and lowest total fat intake was 1.2 points. For the DG/AI/EAR nutrient score, the mean difference was 1.1 points. Compared with <20.0% energy group, the both types of age-adjusted nutrient scores were significantly higher across the other five groups of total fat intake (p<0.05; data not shown). In women, our analyses showed no significant trends in either nutrient score. Total fat intake was positively associated with protein, calcium, thiamin, and riboflavin intakes and inversely associated with carbohydrate and dietary fiber intakes. For both sexes, means of all dietary lipid variables were significantly higher in individuals with higher total fat intake.

Table 3 shows the percentage of individuals who met the DRIs (2015) for each of the six groups of total fat intake (as a percentage of energy including alcohol). For men, the percentage of individuals who met the AI for n-6 and n-3 polyunsaturated fatty acids; the RDA for calcium, iron, and riboflavin; and the EAR for vitamin A, thiamine, and riboflavin was greater in those with higher total fat intake. For women, the percentage of individuals who met the AI for n-6 and n-3 polyunsaturated fatty acids, the RDA for riboflavin, and the EAR for vitamin A was greater in those with higher total fat intake. For both sexes, the percentage of those who did not meet the DG for saturated fatty acids was greater among those with higher total fat intake. The percentage of participants who did not achieve the EAR for calcium and thiamine was 49% and 52%, respectively. For both sexes, the percentage of those whose intake fell below the RDA for protein was extremely low (data not shown).

The participants' consumption of various food groups (in g/day) according to the six groups of total fat intake (as a percentage of energy including alcohol) are shown in Table 4. For men, mean intakes of fats and oils, nuts and seeds, meats, eggs, dairy products, and prepared foods were significantly greater in individuals with higher total fat intake; mean intakes of cereals and beverages were significantly lower in those with higher total fat intake. For women, mean intakes of fats and oils, meats, eggs, and dairy products were significantly greater in those with higher total fat intake; mean intakes of cereals and sugars and sweeteners were significantly lower than in individuals with higher total fat intake.

Similar results were observed regarding the association between total fat intake (as a percentage of energy excluding alcohol) and food group intakes (data not shown). For men, total fat intake was positively associated with intakes of fats and oils, nuts and seeds, meats, eggs, and dairy products, and inversely associated with cereals intake. For women, total fat intake was positively associated with intakes of fats and oils, nuts and seeds, pulses, meats, eggs, dairy products, and beverages, and inversely associated with intakes of cereals, potatoes and starches, sugars and sweeteners, and fruits.

DISCUSSION

The main findings of this study demonstrated that, in combined data from four middle-aged population samples of Japanese people living in Japan, a relatively low mean total fat intake (25% of total energy) showed a significant positive association with intakes of calcium, thiamine, riboflavin, meats, eggs, and milks and dairy products for both sexes. The associations between total fat intake with intakes of various nutrients and food groups were similar regardless of whether energy from alcohol were included or excluded.

Japanese men had one of the highest alcohol intake in the world.[16] Moreover, alcohol consumption has effects on dietary intake in Japanese middle-aged men.[17] Alcoholic beverages contain virtually no nutrients, but contribute to energy intake. Therefore, we calculated the two types of total fat intake as % energy including and excluding alcohol.

For men, total fat intake (% energy, excluding alcohol) was higher than total fat intake (% energy, including alcohol) because most men consumed alcohol. It is important to be careful in reading the numerical values of total fat intake. Although for men, total fat intake (as % energy) was quite varying if including and excluding alcohol intake, similar associations of total fat with other nutrients intake were observed regardless of the method for calculating the total fat intake. However, for women, the two total fat intake values were similar because most women had no alcohol intake.

Total fat intake was associated with intakes of meats, eggs, and milks and dairy products. Increased intakes of these food groups contributed to higher intakes of thiamine, riboflavin, calcium, and saturated fatty acids. The positive correlations between intakes of thiamin and calcium with total fat intake are useful since a significant number of Japanese consume less than optimal levels of these nutrients. Because dietary inadequacy for participants was determined using the EAR cut-point method,[3] the percentage of individuals with calcium and thiamine inadequacy was estimated to be 49% and 52 %, respectively.

Total fat intake was associated with saturated fatty

Table 3. Percentage of individuals who met the Dietary Reference Intakes for Japanese (2015) by total fat intake (as % of energy including alcohol). Participants included 371 men and 401 women with healthy BMI between 40-59 years of age (1997-1999).

	Total fat intake (% energy including alcohol)						
	<20.0%	20.0-22.4%	22.5-24.9%	25.0-27.4%	27.5-29.9%	≥30.0%	Trend *p*
Men							
Number of participants	87	68	71	69	41	35	
SFA†	87 (100)	66 (97.1)	61 (85.9)	37 (53.6)	16 (39.0)	6 (17.1)	<0.001
N-6 PUFA‡	25 (28.7)	45 (66.2)	52 (73.2)	56 (81.2)	39 (95.1)	31 (88.6)	<0.001
N-3 PUFA‡	52 (59.8)	54 (79.4)	63 (88.7)	65 (94.2)	37 (90.2)	34 (97.1)	<0.001
Dietary fiber‡	16 (18.4)	8 (11.8)	13 (18.3)	9 (13.0)	7 (17.1)	6 (17.1)	0.914
Sodium†	6 (6.9)	0 (0.0)	5 (7.0)	4 (5.8)	3 (7.3)	3 (8.6)	0.387
Potassium§	52 (59.8)	45 (66.2)	44 (62.0)	45 (65.2)	27 (65.9)	26 (74.3)	0.202
Calcium¶	20 (23.0)	9 (13.2)	18 (25.4)	29 (42.0)	14 (34.1)	13 (37.1)	0.002
Iron¶	75 (86.2)	64 (94.1)	69 (97.2)	67 (97.1)	41 (100)	35 (100)	<0.001
Vitamin A¶	23 (26.4)	19 (27.9)	19 (26.8)	23 (33.3)	15 (36.6)	14 (40.0)	0.072
Thiamine¶	5 (5.7)	8 (11.8)	8 (11.3)	10 (14.5)	5 (12.2)	5 (14.3)	0.113
Riboflavin¶	35 (40.2)	38 (55.9)	43 (60.6)	52 (75.4)	30 (73.2)	22 (62.9)	<0.001
Vitamin C¶	40 (46.0)	37 (54.4)	36 (50.7)	39 (56.5)	23 (56.1)	20 (57.1)	0.184
Calcium††	31 (35.6)	23 (33.8)	36 (50.7)	41 (59.4)	21 (51.2)	22 (62.9)	<0.001
Iron††	85 (97.7)	67 (98.5)	70 (98.6)	69 (100)	41 (100)	35 (100)	0.109
Vitamin A††	42 (48.3)	36 (52.9)	39 (54.9)	42 (60.9)	24 (58.5)	25 (71.4)	0.016
Thiamine††	25 (28.7)	18 (26.5)	23 (32.4)	30 (43.5)	20 (48.8)	18 (51.4)	0.001
Riboflavin††	67 (77.0)	57 (83.8)	64 (90.1)	64 (92.8)	38 (92.7)	29 (82.9)	0.026
Vitamin C††	54 (62.1)	44 (64.7)	49 (69.0)	44 (63.8)	28 (68.3)	25 (71.4)	0.350
Women							
Number of participants	48	37	68	96	59	93	
SFA†	48 (100)	33 (89.2)	53 (77.9)	45 (46.9)	14 (23.7)	4 (4.3)	<0.001
N-6 PUFA‡	23 (47.9)	26 (70.3)	47 (69.1)	81 (84.4)	52 (88.1)	89 (95.7)	<0.001
N-3 PUFA‡	36 (75.0)	29 (78.4)	52 (76.5)	79 (82.3)	54 (91.5)	88 (94.6)	<0.001
Dietary fiber‡	18 (37.5)	13 (35.1)	20 (29.4)	23 (24.0)	13 (22.0)	19 (20.4)	0.008
Sodium†	4 (8.3)	0 (0.0)	4 (5.9)	5 (5.2)	2 (3.4)	8 (8.6)	0.569
Potassium§	37 (77.1)	31 (83.8)	56 (82.4)	92 (95.8)	50 (84.7)	78 (83.9)	0.288
Calcium¶	14 (29.2)	10 (27.0)	25 (36.8)	37 (38.5)	22 (37.3)	38 (40.9)	0.101
Iron¶	44 (91.7)	36 (97.3)	64 (94.1)	93 (96.9)	57 (96.6)	85 (91.4)	0.763
Vitamin A¶	21 (43.8)	17 (45.9)	31 (45.6)	54 (56.3)	30 (50.8)	51 (54.8)	0.130
Thiamine¶	13 (27.1)	7 (18.9)	21 (30.9)	25 (26.0)	15 (25.4)	21 (22.6)	0.646
Riboflavin¶	25 (52.1)	25 (67.6)	51 (75.0)	84 (87.5)	45 (76.3)	77 (82.8)	<0.001
Vitamin C¶	32 (66.7)	23 (62.2)	40 (58.8)	57 (59.4)	32 (54.2)	56 (60.2)	0.403
Calcium††	21 (43.8)	17 (45.9)	36 (52.9)	58 (60.4)	33 (55.9)	52 (55.9)	0.109
Iron††	47 (97.9)	37 (100.0)	┐ (97.1)	96 (100)	58 (98.3)	90 (96.8)	0.528
Vitamin A††	29 (60.4)	28 (75.7)	50 (73.5)	75 (78.1)	50 (84.7)	75 (80.6)	0.006
Thiamine††	23 (47.9)	22 (59.5)	38 (55.9)	62 (64.6)	32 (54.2)	60 (64.5)	0.118
Riboflavin††	43 (89.6)	31 (83.8)	64 (94.1)	95 (99.0)	55 (93.2)	88 (94.6)	0.069
Vitamin C††	35 (72.9)	26 (70.3)	45 (66.2)	73 (76.0)	44 (74.6)	73 (78.5)	0.206

SFA: saturated fatty acids. PUFA: polyunsaturated fatty acids.
Values are numbers (%).
†Less than tentative dietary goal for preventing life-style related diseases (DG).
‡More than DG§more than adequate intake (AI).
¶More than recommended dietary allowance (RDA).
††More than estimated average requirement (EAR).

acids intake. These results are important because higher saturated fatty acids intake are associated with a higher incidence of hyperlipidemia,[17] diabetes,[18–20] and coronary heart disease.[23] To reduce these risks, the DG upper limit for saturated fatty acids was set at 7.0% of energy including alcohol.[3] For men, average saturated fatty acids intake in the group who consumed 25.0–27.5% of energy from fat reached this upper limit.

Total fat intake was inversely associated with dietary fiber intake in women. Dietary fiber is a nutrient of public health concern owing to its general under-consumption across the Japanese population relative to DG.[3] A growing body of evidence also suggests that dietary fiber may play a role in preventing cardiovascular disease, [24-28] some cancer types,[29,30] and type 2 diabetes.[28,31]

The mean for both nutrient scores were higher in men who consumed more total fat, while there was no association between nutrient scores and total fat intake in women. This may be explained by the fact that the percentage of women with cooking skills was higher than in men, and women eat out less frequently than men do.[32,33] Accordingly, women are more likely to consume a higher quality diet regardless of total fat intake compared with men.

A significant reduction in both DG/AI/RDA and DG/AI/EAR nutrient scores was evident among men who consumed less than 20.0% of total energy from fat, including alcohol, which became evident when the cut points for two types of total fat intake (as a percentage of total energy, including alcohol) were analyzed in descending order. As such, we recommend that the cutoff for total

Table 4. Total fat intake (as % energy including alcohol) and intake by food group (g/day) of Japanese participants between 40-59 years of age (1997-1999) (men=371, women=401).

	Total fat intake (% energy including alcohol)						
	<20.0%	20.0-22.4%	22.5-24.9%	25.0-27.4%	27.5-29.9%	≥30.0%	Trend *p*
Men							
Number of participants	87	68	71	69	41	35	
Cereals	705 (19.9)	626 (22.3)	612 (21.9)	558 (22.1)	554 (28.7)	512 (31.6)	<0.001
Potatoes and starches	48.6 (4.1)	48.4 (4.6)	51.8 (4.5)	42.9 (4.5)	48.5 (5.9)	54.8 (6.5)	0.617
Sugars and sweetners	10.4 (0.7)	11.1 (0.8)	12.4 (0.8)	12.4 (0.8)	12.6 (1.1)	9.1 (1.2)	0.795
Confectioneries	21.0 (3.4)	27.0 (3.8)	28.2 (3.8)	34.6 (3.8)	27.9 (4.9)	31.2 (5.4)	0.111
Fats and oils	7.8 (0.6)	11.2 (0.7)	13.7 (0.7)	14.0 (0.7)	16.2 (0.9)	19.5 (1.0)	<0.001
Nuts and seeds	1.6 (0.8)	4.0 (0.9)	3.7 (0.9)	4.1 (0.9)	5.2 (1.1)	5.1 (1.3)	0.014
Pulses	203 (11.8)	173 (13.3)	201 (13.0)	190 (13.2)	219 (17.1)	193 (18.8)	0.548
Fishes and shellfishes	113 (5.7)	103 (6.4)	108 (6.3)	109 (6.4)	100 (8.3)	103 (9.1)	0.360
Meats	47.6 (4.0)	61.6 (4.5)	65.7 (4.4)	69.2 (4.5)	73.6 (5.8)	79.6 (6.4)	<0.001
Eggs	34.1 (2.9)	41.0 (3.2)	44.0 (3.1)	50.3 (3.2)	54.6 (4.1)	47.7 (4.5)	<0.001
Milks and dairy products	70.8 (11.7)	84.7 (13.1)	112 (12.9)	136 (13.0)	130 (16.9)	173 (18.6)	<0.001
Vegetables	224 (10.6)	235 (11.9)	218 (11.7)	222 (11.8)	247 (15.3)	252 (16.9)	0.124
Fruits	96.5 (10.5)	94.4 (11.7)	89.6 (11.5)	103 (11.7)	102 (15.1)	112 (16.7)	0.320
Fungi	10.4 (1.3)	10.6 (1.5)	9.9 (1.4)	7.6 (1.4)	11.1 (1.9)	10.4 (2.1)	0.952
Algae	8.8 (1.0)	10.6 (1.2)	9.2 (1.1)	7.6 (1.2)	8.6 (1.5)	7.7 (1.7)	0.262
Beverages	1208 (55.0)	1170 (61.5)	981 (60.4)	1042 (61.1)	919 (79.2)	820 (87.3)	<0.001
Seasonings and spices	100 (7.7)	108 (8.6)	118 (8.4)	97.7 (8.5)	99.3 (11.1)	110 (12.2)	0.985
Prepared foods	12.9 (2.4)	14.0 (2.6)	13.2 (2.6)	19.1 (2.6)	24.5 (3.4)	32.2 (3.7)	<0.001
Women							
Number of participants	48	37	68	96	59	93	
Cereals	537 (17.5)	494 (19.4)	460 (14.3)	436 (12.0)	411 (15.3)	365 (12.4)	<0.001
Potatoes and starches	49.6 (5.4)	60.2 (6.0)	52.1 (4.4)	48.5 (3.7)	42.7 (4.8)	45.8 (3.9)	0.070
Sugars and sweetners	15.8 (1.0)	11.4 (1.2)	12.3 (0.9)	10.8 (0.7)	11.4 (0.9)	10.4 (0.7)	<0.001
Confectioneries	43.8 (4.6)	41.4 (5.1)	40.9 (3.8)	46.4 (3.2)	43.2 (4.0)	47.5 (3.3)	0.413
Fats and oils	6.7 (0.8)	7.6 (0.9)	8.9 (0.7)	10.6 (0.6)	13.4 (0.7)	16.5 (0.6)	<0.001
Nuts and seeds	2.3 (1.0)	1.9 (1.1)	2.9 (0.8)	3.3 (0.7)	3.1 (0.8)	5.6 (0.7)	0.006
Pulses	176 (14.3)	192 (15.8)	184 (11.7)	161 (9.8)	165 (12.5)	155 (10.1)	0.055
Fishes and shellfishes	86.3 (6.3)	88.7 (7.0)	84.7 (5.2)	78.9 (4.3)	77.0 (5.5)	79.6 (4.5)	0.126
Meats	26.6 (3.8)	30.7 (4.2)	39.2 (3.1)	41.9 (2.6)	47.0 (3.3)	60.2 (2.7)	<0.001
Eggs	25.3 (2.9)	29.9 (3.2)	32.9 (2.4)	34.7 (2.0)	32.5 (2.5)	40.4 (2.1)	<0.001
Milks and dairy products	70.5 (17.3)	109 (19.2)	148 (14.2)	153 (11.9)	162 (15.2)	194 (12.3)	<0.001
Vegetables	250 (15.5)	245 (17.1)	242 (12.7)	254 (10.6)	249 (13.6)	236 (11.0)	0.689
Fruits	175 (15.9)	151 (17.6)	148 (13.0)	149 (10.9)	152 (13.9)	136 (11.3)	0.116
Fungi	8.2 (1.3)	9.4 (1.5)	10.1 (1.1)	7.6 (0.9)	10.1 (1.2)	10.1 (0.9)	0.385
Algae	5.9 (1.7)	10.7 (1.9)	9.0 (1.4)	7.3 (1.2)	7.5 (1.5)	10.0 (1.2)	0.499
Beverages	630 (55.9)	664 (62.0)	663 (45.8)	659 (38.4)	697 (49.0)	667 (39.7)	0.514
Seasonings and spices	88.0 (7.7)	78.8 (8.5)	75.5 (6.3)	71.8 (5.3)	78.2 (6.7)	82.4 (5.4)	0.567
Prepared foods	9.2 (3.1)	14.9 (3.5)	9.1 (2.6)	13.9 (2.1)	15.6 (2.7)	12.4 (2.2)	0.346

Values are adjusted by age and means (standard errors).

fat intake among men should be set at 20% of total energy in order to ensure nutrient adequacy. Similar results were observed for total fat intake excluding energy from alcohol.

The EAR is used to assess the adequacy of nutrient intake within a group.[3] Although theoretically the percentage of individuals who consume less than the EAR corresponded to the percentage of individuals with a deficiency within the group, it is impossible to determine whether an individual consumed more than the minimum requirement.[3] The EAR is the intake level that corresponds to a 50% probability that an individual consumes an insufficient level of a certain nutrient, and the RDA is the intake level that corresponds to a nearly 0% probability that an individual will experience a deficiency for a certain nutrient. In order to ensure dietary adequacy, an individual should aim to approach achieve the RDA for all nutrients. Therefore, in this study, we assessed nutrient intake using the RDA as well as the EAR.

The components and cutoff values for the nutrient scores were defined based on the DRIs (2015) and dietary fat quality. Besides the decision regarding which nutrients to include, no additional weights were applied. It is not plausible that all nutrients have the same impact on health; however, there is also not enough evidence to define the relative contributions of different nutrients to overall health. Further study is warranted to clarify priorities regarding the impact that various nutrients have on for overall health in Japanese people.

Recommendations for total fat intake need to be weighed against possible threats to nutritional adequacy at the upper or lower boundaries of total fat intake, as well as the role that total fat intake plays in the prevention of life-style related diseases. However, few studies have examined the relationship between total fat intake and intakes of other nutrients consumed by Japanese people.[3] Studies in the United States have shown that total fat intake is positively associated with intakes of protein, sodium, processed and red meats, whole milk and cheese, eggs, and desserts, and inversely associated with intakes of carbohydrates, vitamin C, dietary fiber, vegetables, fruits, cereals, fish, chicken, and low-fat milk.[34,35] Fat intakes are much higher in Western countries than in Japan. Dietary sources of fat should be considered, because even when two foods contain equivalent amounts of fat, foods differ in their micronutrient contents. Therefore, the effects of fat replacement may depend on the diet, which can differ among populations.

The main strengths of this study were: (1) its population-based samples; (2) the standardized collection of high quality nutrition and laboratory measurements; and (3) the use of multiple procedures to ensure quality control. This study was limited by its cross-sectional design. Owing to the cross-sectional nature of this study, the results must be interpreted cautiously in regards to cause-and--effect relationships. We were unable to assess the relationship between energy intake and changes in BMI. However, because food intake patterns change slowly over time, it was reasonable to assume that food intake and hence, energy intakes of participants, remained similar over a substantial period prior to this study. Therefore, we believe that it is appropriate to use healthy BMI as an indicator of adequate energy intake. These findings may not be generalizable to other populations. Especially in particular, because participants in this study were between the ages of 40 and -59 years old, our results limited generalizability to persons within this age range. Fieldwork for the INTERMAP/INTERLIPID studies was conducted from 1997 to 1999, so it is necessary to consider whether the typical Japanese diet has changed since that time. Available data indicates that the Japanese diet has not changed much; according to the National Health and Nutritional Survey in Japan, the percentages of total energy consumed from protein, fat, and carbohydrates were 16.0, 26.3, and 57.7 % in 1998, respectively, compared with 14.9, 26.2, and 58.9% in 2013, respectively.[36,37]

Male participants who consumed more than 27.5% total energy from total fat consumed more than the DG for saturated fatty acids, indicating a higher risk of coronary heart disease and type 2 diabetes. On the other hand, male participants who consumed less than 20% of total energy from total fat had lower nutrient scores, i.e., less desirable nutrient intake levels. From these facts, we consider that fat intake between 20–27% of total energy, including energy from alcohol, is optimal for desirable adequate nutrient intakes in healthy Japanese men aged 40–59 years old with a healthy BMI.

ACKNOWLEDGMENTS

We thank all INTERMAP and INTERLIPID staff at the local, national, and international centers for their invaluable efforts; a partial listing of these colleagues is cited in References 6 and 8 of this manuscript.

AUTHOR DISCLOSURES

This study was supported in part by a grant–in–aid of the Japanese Ministry of Education, Culture, Sports, Science and Technology (Grant–in–aid for Scientific Research: (A) 090357003, (C) 17590563, and (C) 19590655) in Japan and by the Suntory Company. The INTERMAP Study is supported by the National Heart, Lung, and Blood Institute, National Institutes of Health, Bethesda, MD, U.S.A. (Grant 2–ROI–HL504090).

REFERENCES

1. Institutes of Medicine. Panel on Macronutrients, Panel on the Definition of Dietary Fiber, Subcommittee on Upper Reference Levels of Nutrients, Subcommittee on Interpretation and Uses of Dietary Reference intakes, and the Standard Committee on the Scientific Evaluation of Dietary Reference Intakes. Dietary Reference Intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein and amino acids. Washington, DC: The National Academies Press; 2005.
2. EFSA Panel on Dietetic Products, Nutrition, and Allergies. Scientific opinion in dietary reference values for fats, including saturated fatty acids, polyunsaturated fatty acids, monounsaturated fatty acids, trans fatty acids, cholesterol. The EFSA J. 2010;8:1461. doi:10.2903/j.efsa.2010.1461.
3. Hishida A, Sasaki S. Dietary reference intakes for Japanese, 2015. Tokyo: Dai-ichi Shuppan; 2014.
4. Elmadfa I, Kornsteiner M. Dietary fat intake--a global perspective. Ann Nutr Metab. 2009;54:8-14. doi: 10.1159/00 0220822.
5. Zhou BF, Stamler J, Dennis B, Moag-Stahlberg A, Okuda N, Robertson C, Zhao L, Chan Q, Elliott P, INTERMAP Research Group. Nutrient intakes of middle-aged men and women in China, Japan, United Kingdom, and United States

in the late 1990s: the INTERMAP study. J Hum Hypertens. 2003;17:623-30.
6. Stamler J, Elliott P, Dennis B, Dyer AR, Kesteloot H, Liu K, Ueshima H, Zhou BF; INTERMAP Research Group. Background, aims, design, methods, and descriptive statistics (nondietary). J Hum Hypertens. 2003;17:591-608.
7. Dennis B, Stamler J, Buzzard M, Conway R, Elliott P, Moag-Stahlberg A et al. INTERMAP: the dietary data-process and quality control. J Hum Hypertens. 2003;17:609-22.
8. Ueshima H, Okayama A, Saitoh S, Nakagawa H, Rodriguez B, Sakata K, Okuda N, Choudhury SR, Curb JD; INTERLIPID Research Group. Differences in cardiovascular disease risk factors between Japanese in Japan and Japanese–Americans in Hawaii: the INTERLIPID study. J Hum Hypertens. 2003;17:631-9.
9. Nakamura M, Morita M, Yabuuchi E, Yukami M, Kuruma S, Kuritani C et al. The evaluation and the results of cooperative cholesterol and triglyceride standardization program by WHO-CDC. Rinsho Byori. 1982;30:325-32.
10. Myers GL, Kimberly MM, Waymack PP, Smith SJ, Cooper GR, Sampson EJ. A reference method laboratory network for cholesterol: a model for standardization and improvement of clinical laboratory measurements. Clin Chem. 2000;46:762-72.
11. Science and Technology Agency. Standard tables of food composition in Japan 4th revised edition. Tokyo: Printing Bureau, Ministry of Finance; 1982.
12. Yoshita K, Miura K, Okayama A, Okuda N, Schakel SF, Dennis B et al. A validation study on food composition tables for the international cooperative INTERMAP study in Japan. Environ Health Prev Med. 2005;10:150-6. doi: 10.1007/BF02900808.
13. Sasaki S. Dietary reference intakes for Japanese 2010: Basic concepts for application. J Nutr Sci Vitaminol. 2013;59:S18-25.
14. Keys A. Serum cholesterol response to dietary cholesterol. Am J Clin Nutr; 1984:40:351-9.
15. Ezaki O, Miyake Y, Sato S, Iso H. Dietary reference intakes for Japanese 2010: Fat. J Nutr Sci Vitaminol. 2013;59:S44-52.
16. World Health Organization. Global Status Report on Alcohol and Health 2014. [cited 2016/05/03] Available from: http://www.who.int/substance_abuse/publications/global_alcohol_report/en/
17. Yoshita K. The Relationships between alcohol, food and nutrient intakes and health examination results. JACD. 1998; 33:186-98.
18. Mensink RP, Zock PL, Kester AD, Katan MB. Effects of dietary fatty acids and carbohydrates on the ratio of serum total to HDL cholesterol and on serum lipids and apolipoproteins: a meta-analysis of 60 controlled trials. Am J Clin Nutr. 2003;77:1146-55.
19. Jakobsen MU, O'Reilly EJ, Heitmann BL, Pereira MA, Bälter K, Fraser GE et al. Major types of dietary fat and risk of coronary heart disease: a pooled analysis of 11 cohort studies. Am J Clin Nutr. 2009;89:1425-32. doi: 10.3945/ajcn.2008.27124.
20. Risérus U, Willett WC, Hu FB. Dietary fats and prevention of type 2 diabetes. Prog Lipid Res. 2009;48:44-51. doi: 10.1016/j.plipres.2008.10.002.
21. Salmerón J, Hu FB, Manson JE, Stampfer MJ, Colditz GA, Rimm EB, Willett WC. Dietary fat intake and risk of type 2 diabetes in women. Am J Clin Nutr. 2001;73:1019-26.
22. van Dam RM, Willett WC, Rimm EB, Stampfer MJ, Hu FB. Dietary fat and meat intake in relation to risk of type 2 diabetes in men. Diabetes Care. 2002;25:417-24.
23. Yamagishi K, Iso H, Kokubo Y, Saito I, Yatsuya H, Ishihara J, Inoue M, Tsugane S, JPHC Study Group. Dietary intake of saturated fatty acids and incident stroke and coronary heart disease in Japanese communities: the JPHC Study. Eur Heart J. 2013;34:1225-32. doi: 10.1093/eurheartj/eht043.
24. Pereira MA, O'Reilly E, Augustsson K, Fraser GE, Goldbourt U, Heitmann BL et al. Dietary fiber and risk of coronary heart disease: a pooled analysis of cohort studies. Arch Intern Med. 2004;164:370-6.
25. Threapleton DE, Greenwood DC, Evans CE, Cleghorn CL, Nykjaer C, Woodhead C, Cade JE, Gale CP, Burley VJ. Dietary fibre intake and risk of cardiovascular disease: systematic review and meta-analysis. BMJ. 2013;347:f6879. doi: 10.1136/bmj.f6879.
26. Threapleton DE, Greenwood DC, Evans CE, Cleghorn CL, Nykjaer C, Woodhead C, Cade JE, Gale CP, Burley VJ. Dietary fiber intake and risk of first stroke: a systematic review and meta-analysis. Stroke. 2013;44:1360-8. doi: 10.1161/STROKEAHA.111.000151.
27. Chen GC, Lv DB, Pang Z, Dong JY, Liu QF. Dietary fiber intake and stroke risk: a meta-analysis of prospective cohort studies. Eur J Clin Nutr. 2013;67:96-100. doi: 10.1038/ejcn.2012.158.
28. Ye EQ, Chacko SA, Chou EL, Kugizaki M, Liu S. Greater whole-grain intake is associated with lower risk of type 2 diabetes, cardiovascular disease, and weight gain. J Nutr. 2012;142:1304-13. doi: 10.3945/jn.111.155325.
29. Dong JY, He K, Wang P, Qin LQ. Dietary fiber intake and risk of breast cancer: a meta-analysis of prospective cohort studies. Am J Clin Nutr. 2011;94:900-5. doi: 10.3945/ajcn.111.015578.
30. Zhang Z, Xu G, Ma M, Yang J, Liu X. Dietary fiber intake reduces risk for gastric cancer: a meta-analysis. Gastroenterology. 2013;145:113-20. doi: 10.1053/j.gastro.2013.04.001.
31. Schulze MB, Schulz M, Heidemann C, Schienkiewitz A, Hoffmann K, Boeing H. Fiber and magnesium intake and incidence of type 2 diabetes: a prospective study and meta-analysis. Arch Intern Med. 2007;167:956-65.
32. Ministry of Health, Labour, and Welfare. National nutrition survey in Japan, 1999 [cited 2015/08/19]. Available from: http://www.mhlw.go.jp/houdou/0103/h0309-7.html.
33. Ministry of Health, Labour, and Welfare. National nutrition survey in Japan, 2000. [cited 2015/08/19] . Available from: http://www.mhlw.go.jp/houdou/0111/h1108-3b.html.
34. Subar AF, Ziegler RG, Patterson BH, Ursin G, Graubard B. US dietary patterns associated with fat intake: the 1987 National Health Interview Survey. Am J Public Health. 1994; 84:359-66.
35. Ursin G, Ziegler RG, Subar AF, Graubard BI, Haile RW, Hoover R. Dietary patterns associated with a low–fat diet in the national health examination follow–up study: identification of potential confounders for epidemiologic analyses. Am J Epidemiol. 1993;137:916-27.
36. Ministry of Health, Labour, and Welfare. National nutrition survey, 1998. [cited 2015/08/19] Available from: http://www1.mhlw.go.jp/toukei/k-eiyou_11/t0225-1.html
37. Ministry of Health, Labour, and Welfare. National health and nutrition survey in Japan, 2013. [cited 2015/08/19] Available from: http://www.mhlw.go.jp/bunya/kenkou/eiyou/dl/h25-houkoku.pdf.

Appendix. Daily nutrient intake and total fat intake (% energy excluding alcohol). Participants included 371 men and 401 women with healthy BMI between 40-59 years of age (1997-1999).

	Total fat intake (% energy excluding alcohol)						
	<20.0%	20.0-22.4%	22.5-24.9%	25.0-27.4%	27.5-29.9%	≥30.0%	Trend *p*
Men							
Number of participants	44	52	66	63	64	82	
Nutrient score (RDA/AI/DG)	4.8 (0.3)	5.1 (0.3)	6.1 (0.3)	6.1 (0.3)	6.3 (0.3)	6.0 (0.2)	<0.001
Nutrient score (EAR/AI/DG)	6.1 (0.3)	6.3 (0.3)	7.2 (0.3)	7.3 (0.3)	7.5 (0.3)	7.2 (0.2)	<0.001
Energy (kcal)	2272 (62)	2118 (58)	2236 (51)	2260 (52)	2339 (52)	2320 (46)	0.044
No alcohol energy (kcal)	2116 (59)	1921 (55)	2057 (48)	2086 (49)	2111 (49)	2125 (43)	0.138
Protein (g)	80.9 (2.7)	80.5 (2.5)	85.8 (2.2)	89.1 (2.3)	92.1 (2.2)	91.0 (2.0)	<0.001
Protein (%E)	15.4 (0.4)	17.0 (0.4)	16.9 (0.3)	17.2 (0.3)	17.6 (0.3)	17.2 (0.3)	<0.001
Total fat (g)	40.0 (1.8)	46.1 (1.7)	54.3 (1.5)	61.2 (1.5)	67.1 (1.5)	76.9 (1.3)	<0.001
Total fat (%E)	17.1 (0.2)	21.6 (0.2)	23.8 (0.2)	26.4 (0.2)	28.7 (0.2)	32.5 (0.2)	<0.001
SFA (g)	10.2 (0.6)	11.7 (0.6)	13.9 (0.5)	15.8 (0.5)	17.9 (0.5)	20.1 (0.5)	<0.001
SFA (%E)	4.4 (0.2)	5.5 (0.2)	6.1 (0.1)	6.9 (0.1)	7.6 (0.1)	8.4 (0.1)	<0.001
N-6 PUFA (g)	8.4 (0.5)	9.6 (0.5)	11.1 (0.4)	12.5 (0.4)	13.2 (0.4)	15.2 (0.4)	<0.001
N-3 PUFA (g)	2.4 (0.2)	2.6 (0.1)	3.0 (0.1)	3.3 (0.1)	3.6 (0.1)	4.1 (0.1)	<0.001
Cholesterol (mg)	302 (25)	409 (23)	418 (21)	486 (21)	461 (21)	499 (19)	<0.001
Keys dietary lipid score	22.3 (0.8)	26.7 (0.7)	27.4 (0.6)	30.4 (0.7)	30.6 (0.6)	32.2 (0.6)	<0.001
Carbohydrates (g)	357 (9.3)	296 (8.6)	306 (7.6)	294 (7.8)	284 (7.7)	267 (6.8)	<0.001
Carbohydrates (%E)	67.4 (0.5)	61.4 (0.4)	59.2 (0.4)	56.3 (0.4)	53.6 (0.4)	50.2 (0.4)	<0.001
Alcohol (g)	22.3 (3.6)	28.2 (3.3)	25.5 (3.0)	25.0 (3.0)	32.6 (3.0)	27.8 (2.7)	0.132
Dietary fiber (g)	15.7 (0.7)	14.6 (0.7)	16.0 (0.6)	16.0 (0.6)	14.9 (0.6)	14.9 (0.5)	0.595
Sodium (mg)	4761 (183)	4951 (169)	4968 (149)	5060 (153)	5161 (152)	5048 (134)	0.110
Potassium (mg)	2771 (104)	2555 (95)	2924 (84)	2922 (86)	2975 (86)	2890 (76)	0.015
Calcium (mg)	570 (33)	511 (30)	583 (27)	610 (27)	648 (27)	633 (24)	0.002
Iron (mg)	10.3 (0.4)	10.4 (0.4)	11.3 (0.3)	11.4 (0.4)	11.7 (0.4)	11.5 (0.3)	0.001
Vitamin A (μgRAE)	755 (125)	961 (115)	873 (102)	760 (104)	1012 (103)	870 (91)	0.500
Thiamine (mg)	0.91 (0.04)	0.86 (0.04)	0.94 (0.03)	0.99 (0.03)	1.05 (0.03)	1.01 (0.03)	<0.001
Riboflavin (mg)	1.26 (0.06)	1.38 (0.06)	1.47 (0.05)	1.50 (0.05)	1.57 (0.05)	1.56 (0.04)	<0.001
Vitamin C (mg)	128 (11)	104 (11)	136 (9)	122 (10)	123 (10)	124 (8)	0.744

%E: percent energy excluding alcohol; SFA: saturated fatty acids; PUFA: polyunsaturated fatty acids; RAE: retinol activity equivalent.
Values are adjusted by age and means (standard errors). %E, percent energy excluding alcohol.

Appendix. Daily nutrient intake and total fat intake (% energy excluding alcohol). Participants included 371 men and 401 women with healthy BMI between 40-59 years of age (1997-1999) (cont.).

	Total fat intake (% energy excluding alcohol)						
	<20.0%	20.0-22.4%	22.5-24.9%	25.0-27.4%	27.5-29.9%	≥30.0%	Trend *p*
Women							
Number of participants	36	36	63	97	60	109	
Nutrient score (RDA/AI/DG)	6.3 (0.3)	6.6 (0.3)	7.2 (0.3)	6.9 (0.2)	6.8 (0.3)	6.5 (0.2)	0.560
Nutrient score (EAR/AI/DG)	7.4 (0.3)	7.8 (0.3)	8.1 (0.2)	8.0 (0.2)	8.1 (0.2)	7.7 (0.2)	0.411
Energy (kcal)	1793 (54)	1725 (54)	1784 (40)	1752 (32)	1788 (41)	1858 (31)	0.212
No alcohol energy (kcal)	1784 (54)	1709 (54)	1753 (40)	1735 (32)	1770 (41)	1808 (31)	0.456
Protein (g)	68.3 (2.6)	65.6 (2.6)	73.2 (1.9)	69.9 (1.6)	71.2 (2.0)	74.7 (1.5)	0.015
Protein (%E)	15.3 (0.4)	15.4 (0.4)	16.7 (0.3)	16.2 (0.2)	16.1 (0.3)	16.6 (0.2)	0.005
Total fat (g)	34.9 (1.8)	40.4 (1.8)	46.4 (1.3)	50.9 (1.1)	56.5 (1.3)	66.9 (1.0)	<0.001
Total fat (%E)	17.2 (0.3)	20.6 (0.3)	23.3 (0.2)	25.8 (0.2)	28.1 (0.2)	32.1 (0.2)	<0.001
Saturated fat (g)	8.6 (0.6)	10.5 (0.6)	12.4 (0.5)	13.9 (0.4)	15.3 (0.5)	18.5 (0.4)	<0.001
Saturated fat (%E)	4.3 (0.2)	5.5 (0.2)	6.4 (0.1)	7.2 (0.1)	7.8 (0.2)	9.2 (0.1)	<0.001
N-6 PUFA (g)	7.5 (0.5)	8.9 (0.5)	9.3 (0.4)	10.1 (0.3)	11.4 (0.4)	12.8 (0.3)	<0.001
N-3 PUFA (g)	2.1 (0.1)	2.2 (0.1)	2.6 (0.1)	2.5 (0.1)	2.9 (0.1)	3.1 (0.1)	<0.001
Cholesterol (mg)	288 (22)	292 (22)	339 (16)	347 (13)	347 (17)	419 (13)	<0.001
Keys dietary lipid score	23.9 (0.9)	26.1 (0.9)	29.0 (0.7)	31.4 (0.5)	31.5 (0.7)	35.8 (0.5)	<0.001
Carbohydrates (g)	299 (8)	270 (8)	260 (6)	249 (5)	244 (6)	227 (5)	<0.001
Carbohydrates (%E)	67.1 (0.5)	63.3 (0.5)	59.4 (0.4)	57.4 (0.3)	55.1 (0.4)	50.1 (0.3)	<0.001
Alcohol (g)	1.3 (1.3)	2.4 (1.3)	4.5 (1.0)	2.5 (0.8)	2.6 (1.0)	7.1 (0.8)	0.004
Dietary fiber (g)	17.6 (0.8)	17.1 (0.8)	16.1 (0.6)	15.6 (0.5)	15.6 (0.6)	14.5 (0.5)	0.001
Sodium (mg)	4404 (183)	4019 (183)	4424 (136)	4094 (109)	4158 (139)	4141 (104)	0.347
Potassium (mg)	2598 (114)	2567 (114)	2759 (85)	2613 (68)	2682 (86)	2695 (65)	0.398
Calcium (mg)	516 (38)	561 (37)	621 (28)	599 (22)	620 (28)	641 (21)	0.004
Iron (mg)	9.3 (0.4)	9.6 (0.4)	10.2 (0.3)	9.9 (0.3)	10.0 (0.3)	9.8 (0.2)	0.282
Vitamin A (μgRAE)	783 (89)	760 (89)	777 (66)	829 (53)	945 (68)	858 (51)	0.123
Thiamine (mg)	0.82 (0.0)	0.79 (0.0)	0.86 (0.0)	0.85 (0.0)	0.87 (0.0)	0.89 (0.0)	0.024
Riboflavin (mg)	1.07 (0.1)	1.08 (0.1)	1.30 (0.0)	1.28 (0.0)	1.31 (0.0)	1.44 (0.0)	<0.001
Vitamin C (mg)	146 (12)	138 (12)	134 (9)	128 (7)	133 (9)	127 (7)	0.192

%E: percent energy excluding alcohol; SFA: saturated fatty acids; PUFA: polyunsaturated fatty acids; RAE: retinol activity equivalent.
Values are adjusted by age and means (standard errors).