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ORIGINAL CONTRIBUTION

Trends in dietary fiber intake in Japan over the last century

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Summary *Background* Insufficient intake of dietary fiber (DF) is currently a major problem in the overall promotion of health in the general population in Japan. *Aim of the study* To analyze the time trends in DF intake, including DF density (total DF intake/1,000 kcal), and the ratio of water-insoluble fiber to water-soluble fiber (IS ratio) in Japan. *Methods* The time trend in DF intake in Japan was calculated from data compiled in the Japanese National Nutrition Survey. *Results* The mean daily DF intake (total DF intake) in 1952 was 20.5 g/day, which rapidly declined to about 70 % of the 1952 level in 1970, after which there was little change to 1998. DF density in 1952 was 9.7 g/1000 kcal, which declined by about 30 % in 1970, and remained at about the same level to 1998. The IS ratio has remained stable over this period. Whereas total DF intake and DF density in Japan are similar to those in Western countries, the IS ratios are higher in Japan. Therefore, the higher incidence of, and mortality from, colon diverticulosis, coronary heart disease, hyperlipidemia, etc., which are all thought to be related to fiber deficiency, in Western countries compared to Japan might be due to the differences in the IS ratio. *Conclusions* A decline in total DF intake and DF density is predicted for Japan in the future, because these parameters were lower among the younger generation. This may be due to the marked changes in the dietary habits of the younger generation, and is a problematic trend for Japanese health.

Key words dietary fiber – dietary fiber density – ratio of water-insoluble fiber to water-soluble fiber – chronological change – Japan

Introduction

The physiological roles of dietary fiber (DF) have been of interest since Burkitt initially presented his well-known hypothesis associating DF depletion with the etiology of so-called fiber-deficiency diseases [1]. Fiber-deficiency diseases are thought to include: colon diverticulosis, colorectal cancer, coronary heart disease, hyperlipidemia, etc. [1–4]. Therefore, recommended levels of daily DF intake have been proposed in many countries, such as 25–35 g by the USA Food and Drug Administration (FDA) [5], and 20–25 g by the Ministry of Health and Welfare in Japan [6]. However, the average daily DF intake (total DF intake) is only 15–18 g in Japan [7–11], and similar amounts have been reported in most Western countries [12–16]. Insufficient intake of DF is thus a major problem in the overall promotion of health in the general population today.

Japan is one of the few countries in the world for which complete nutritional data from World War II to the present are available, and therefore this presents a

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unique opportunity to examine the relationship between DF and fiber-deficiency diseases.

DF includes two components: water-insoluble fiber and water-soluble fiber. These components have different physiological effects, and different nutritional impacts [17–20]. Digestion in the small intestine is affected mainly by water-soluble DF, represented by pectin, while the regulation of large intestine functions and fecal excretion are associated mainly with water-insoluble DF, represented by cellulose, hemicellulose, and lignin [17–20]. Despite such differences in effects, no study has estimated the intake ratio of water-insoluble to soluble-fiber (IS ratio), largely because of the lack of basic data for the estimation of intakes of these fiber components.

We analyzed the time trends in DF intake, total DF intake per 1,000 kcal (DF density), and IS ratio in Japan, and extrapolated these data to predict future trends.

Materials and methods

Data sources

To analyze the Japanese DF intake, we extracted data from the series of Japanese National Nutrition Surveys that have been carried out every year throughout Japan since 1946 [21]. In these surveys, food consumption by families enrolled in the study was assessed by weighing food items consumed on three consecutive weekdays (until 1994) or on one weekday (from 1995).

The dietary survey was performed as follows. A staff dietitian demonstrated the survey methods and procedures to the housewife or whoever usually cooked for the family. The responsible person in each household weighed and recorded the cooked dishes and the ingredients for each dish, the amount consumed and any left uneaten, and the approximate proportion of each dish or food consumed by each family member. The type and amount of food eaten outside the home was also recorded as part of the meals taken by each individual. The mean values for dietary intake are given per capita. The sample of this survey was selected at random by the Ministry of Health and Welfare. The sample population was about 15,000 persons in 150 regions.

Calculation of DF

DF intake per capita, including water-soluble and water-insoluble fiber, was calculated as follows. The DF content (i. e., both water-soluble fiber and water insoluble fiber content) for each food was available from the Dietary Fiber Table [7, 22], which was calculated by the modified Prosky method [23]. These DF content values were substituted into the intake value for each food, from the results of the National Nutrition Survey; daily intake of total DF per capita (for both water-soluble fiber and water insoluble fiber) were then calculated by combining these.

DF was defined as a substance not contained in animal foods, which is, according to Trowell's definition, "the skeletal remains of plant cells that are resistant to hydrolysis by the enzymes of man" [24], and, according to the definition of the US FDA, "the final products in dietary substances resistant to the human digestive enzymes" [5]. Resistant starch, which is thought by some researchers to be a more important factor in large bowel function and health than DF [25], was not calculated because of a lack of data.

Results

Total DF intake

The mean total daily DF intake in 1952 was calculated as 20.5 g/day, which rapidly declined to about 70 % of the 1952 level in 1970 (Table 1), with little change thereafter to 1998. This decreasing trend mainly depended on decreases in intakes of rice and beans.

DF density

DF density data are given in Table 2. The highest level was noted in 1952, when DF density was 9.7 g/1,000 kcal. Thereafter, a rapid decline occurred, reaching about 70 % of the 1952 level in 1970, followed by a slight increase in DF density to 1998.

IS ratio

Intakes of both water-insoluble fiber and water-soluble fiber have decreased since 1952 (Table 2). However, whereas the IS ratio was 3.61 in 1952, it increased slightly to 4.03 in 1970. Since then, there has been little change to 1998 (Table 2). Therefore, in general, the IS ratio in Japan has been stable over this period.

Total DF intake, DF density, and IS ratio by age and sex

Results show that total DF intake, DF density and IS ratio increase with age (Table 3). These three values, especially DF density, were greater in men than in women in all age groups.

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Table 1 Chronological change in dietary fiber intake in Japan

	Year					
	1952	1960	1970	1980	1990	1998
Food group						
Rice	2.5[a] (12.4[b])	2.6 (13.7)	2.2 (14.8)	1.6 (10.7)	1.4 (9.9)	1.2 (7.9)
Barley & wheat	5.1 (25.0)	3.3 (17.6)	1.9 (12.8)	2.5 (16.2)	2.3 (16.1)	2.5 (16.4)
Seeds	0.0 (0.2)	0.0 (0.2)	0.1 (1.0)	0.1 (0.7)	0.1 (0.7)	0.2 (1.1)
Potatoes	1.7 (8.1)	1.1 (5.7)	1.0 (6.7)	1.1 (7.0)	1.0 (7.2)	1.2 (7.7)
Confectionaries	0.0 (0.0)	0.0 (0.0)	0.7 (4.7)	0.5 (3.0)	0.4 (2.5)	0.4 (2.9)
Beans	5.2 (25.5)	5.7 (30.4)	2.1 (14.1)	1.9 (12.5)	2.0 (13.6)	2.1 (14.1)
Fruits	0.6 (3.1)	0.9 (4.7)	1.1 (7.4)	1.9 (12.7)	1.5 (10.5)	1.3 (9.0)
Vegetables	4.5 (21.9)	4.3 (23.1)	4.6 (30.9)	4.3 (28.2)	4.1 (28.7)	4.5 (29.9)
Mushrooms	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.3 (1.7)	0.3 (2.3)	0.4 (3.0)
Seaweeds	0.8 (3.7)	0.9 (4.6)	1.3 (8.7)	0.9 (6.1)	1.1 (7.7)	1.1 (7.3)
Others	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.2 (1.1)	0.1 (0.4)	0.1 (0.4)
Total	20.5 (100)	18.8 (100)	14.9 (100)	15.2 (100)	14.4 (100)	15.0 (100)

[a] g/day; [b] percentage to total fiber intake

Table 2 Annual changes in DF density and IS ratio

	Year					
	1952	1960	1970	1980	1990	1998
DF density[a]	9.7	9.0	6.8	7.3	7.1	7.4
IS ratio[b]	3.61	3.83	3.99	3.69	3.74	3.73
Water-insoluble fiber (g)	16.1	14.9	11.9	12.0	11.4	11.8
Water-soluble fiber (g)	4.4	3.9	3.0	3.2	3.0	3.2

[a] DF intake/1,000 kcal
[b] *IS ratio* Water-insoluble DF/water-soluble DF

Table 3 Total dietary fiber intake, fiber density and IS ratio by age group

	Total dietary fiber intake(g/day)		IS ratio	
Age group	Male	Female	Male	Female
15–19	14.4	13.4	3.71	3.66
20–29	13.7	13.5	3.80	3.67
30–39	14.5	13.8	3.81	3.66
40–49	15.1	14.8	3.82	3.67
50–59	17.5	17.0	3.84	3.68
60–69	17.8	16.8	3.82	3.70
Over 70	16.5	15.1	3.82	3.75
	Dietary fiber intake per 1,000 kcal			
Age group	Male	Female		
20–29	6.87	6.71		
30–39	6.94	6.39		
40–49	6.86	6.43		
50–59	8.10	7.34		
60–69	9.19	8.34		
Over 70	9.14	8.01		

Discussion

There are many reports describing total DF intake measurements in Japan [7–11, 26–38]. Although different measuring methods have been used in these studies, the daily DF intake among the Japanese population has been consistently found to be in the range of 15 to 20 g/day in the 1980s and 1990s (Table 4). Researchers studying DF intake in Japan (Ohi et al. [30], Munakata et al. [4], Ohta et al. [8], Ikegami et al. [11], and the Japan Association of Prefectural and Municipal Public Health Institutes [7]) have all observed a reduction of 20–30 % over the last 30 years.

In the USA, findings have been less consistent. Lanza et al. calculated DF intake from the Second National Health and Nutrition Examination Survey (NHANES II) and found values of 12.9 g for males and 9.4 g for females [12]. The NHANES III Study showed a DF intake of 17.0 g for males and 12.8 g for females. Anderson et al. [39], using the results of the Nationwide Food Consumption Survey, reported a mean DF intake of 11.4 g, whereas, more recently, Tillotson et al. [13] reported a mean DF intake of 13.7 g in total, comprising 4.2 g of water-soluble DF and 6.8 g of water-insoluble DF. In contrast, Hallfrisch et al. [40] and Hermann et al. [41] reported 15 g/day and 18.3 g/day, respectively, for the US population. In Europe, estimated national values for DF intake fall within a narrow range: 16 g/day in France [42] 22.1 g/day in Sweden [14], 16.7–20.1 g/day in Finland [15], 21 g/day in Germany [43], and 20–22 g/day in the Netherlands [16], with one exceptionally high value of 30–33 g/day in Switzerland [44]. In the UK, Emmett et al. [45] found lower values of 14–16 g/day for men and 18–19 g/day for women. From these reports we can deduce that DF intake among the Japanese population is similar to that of Western countries, although it is difficult to directly compare DF intake in Japan

Table 4 Dietary fiber intake in Japanese individuals, by article

Author	Report year	Measurement method	Subject	Daily dietary fiber intake (year(s) studied)
Nakashima et al. [26]	1980	Van Soest	Student meals	15.8 (1979)
Mori et al. [27]	1981	Southgate	Student meals	15–19 (1979)
Kuratsue et al. [28]	1983	Southgate	All Japanese	10.90–12.86 (1970–1979)
Minowa et al. [29]	1983	Southgate	All Japanese	19.4 (1979)
			Ten largest cities	17.4 (1979)
			Towns and villages	20.2 (1979)
Ohi et al. [30]	1983	Southgate	All Japanese	24 (1970s)
Bright-See et al. [31]	1984	Southgate	All Japanese	31.9 (1972–1974)
Ohta et al. [8]	1985	Southgate	General population in Aomori	21.1 (1983)
Ohta et al. [9]	1987	Southgate	General population in Aomori	19.9 (1984)
Munakata et al. [32]	1987	Southgate	All Japanese	16.2–21.1 (1983)
Sumimoto et al. [33]	1989	Prosky	All Japanese	19.6 (1989)
		Prosky	All Japanese	18.6 (1989)
Nishimune et al. [34]	1993	Prosky	All Japanese	15.9–22.3 (1951–1990)
JAPMPHI et al. [7]	1993	Prosky	All Japanese	17.4 (1985)
Nakaji et al. [35]	1993	Southgate	General population in Aomori	18.8 (1991)
		Prosky	General population in Aomori	17.6 (1991)
Nakaji et al. [10]	1993	Southgate	All Japanese	13.5–20.5 (1984–1991)
		Prosky	All Japanese	12.4–19.3 (1984–1991)
Ikegami et al. [11]	1996	Prosky	All Japanese	15.5–21.3 (1951–1992)
Shimbo et al. [36]	1996	Prosky	General population	20.7 (1979–1983)
				18.7 (1990–1995)
Nagayama et al. [37]	1998	Prosky	General population in Tottori	18.67 (male, 1993)
				17.81 (female, 1993)
Yoshioka et al. [38]	1999	Prosky	All Japanese (male)	16.8 (1996)
			All Japanese (female)	16.9 (1996)

JAPMPHI Japan Association of Prefectural and Municipal Public Health Institute

with other countries because measurement methods differ.

In the USA, DF density was reported to be 5.5 g/1,000 kcal in men and 6.5 g/1,000 kcal in women in 1976–1980 by NHANES II [12] using the Prosky method; and 6.9 g/1,000 kcal in men, and 7.4 g/1,000 kcal in women in 1988–1991 by NHANES III [46]. These values are similar to, although lower than, the Japanese values: 7.3 g/1,000 kcal in 1980 and 7.1 g/1,000 kcal in 1990 for both sexes (Table 2). In contrast, the IS ratio presented here for the Japanese population is far higher than that of 1.62 reported by Tillotson et al. for the USA [13]. However, the authors could not find any reports other than Tilloton's regarding the intake of water-insoluble fiber and water-soluble fiber in Western countries.

As already noted above, Japan is one of the few countries in the world that has complete nutritional data from World War II to the present, as well as data on the main causes of mortality and incidence of major diseases [21, 47]. Therefore, we are in a unique position to assess the relationship between dietary habits and so-called fiber-deficiency diseases such as colon diverticulosis, colorectal cancer, coronary heart disease, hyperlipidemia etc. Indeed the prevalence of these diseases/states has increased in parallel with decreasing intakes of total DF intake, DF density, water-insoluble fiber and water-soluble fiber after World War II [21, 47]. This notwithstanding, the relationship between DF and prevalence of colorectal cancers is not straightforward: Nakaji et al. examined the correlation between DF intake around 1990 and the standardized mortality ratios of colon and rectal cancer between 1995 and 1997 in 23 Japanese prefectures, but failed to show any protective effect of DF against colorectal cancer [48]. This discrepancy in Japan is similar to the ongoing debate about the effects of DF on colorectal cancer in Western countries; although there are many reports of the protective effect on colorectal carcinogenesis, many researchers have questioned the protective effects of DF against colon carcinogenesis since the negative reports of Fuchs et al. in 1999 [49] and of Schatzkin et al. [50] and Alberts et al. in 2000 [51]. In the case of colon diverticulosis, Munakata et al. reported a significant negative correlation between DF intake and the incidence of colonic diverticulosis in five regions of Japan [4], mirroring the chronological relationship between DF intake and incidence/detection rates of this disease in Japan as reported here. There is as yet no cross-sectional study on coronary heart disease and hyperlipidemia in Japan.

IS ratios differ significantly for Japan and USA, despite the similar levels of both total DF intake and DF density. Therefore, the greater incidence/mortality from fiber-deficiency diseases in Western countries than in Japan [4, 21, 47, 52, 53] might potentially be due to this difference in IS ratio. However, interpretation of the relationship between IS ratio and fiber-deficiency diseases

is difficult, because, for example, no change in the IS ratio from the Second World War could explain the increase in colon diverticulosis, diabetes mellitus and obesity. Furthermore, there are little data regarding water-insoluble fiber and water-soluble fiber in western countries. Therefore, further studies on IS ratio and its relationship to fiber-deficiency diseases are indicated in the future.

In the present study, there was a small change in total DF intake from 1970 to 1998, but a more marked decline in total DF intake is predicted for Japan in the future because DF intake was found to be significantly lower in the younger generation. This may be due to the marked change in dietary habits in the younger generation. In particular, the intake of rice, which is the main source of DF for the Japanese population, is decreasing among the younger generation, and this may be a factor accelerating the reduction in DF intake in the near future. The time trend in DF density is similar to that of total DF intake, in contrast to the stability of the IS ratio. This trend is seen across the whole of Japan and is a cause for concern for Japanese health in the future.

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