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Original Article

Estimated daily intake of biotin in hospital meals in Japan through dietary surveillance

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Summary

We determined the biotin content in hospital meals using different dietary surveys such as "food group calculation survey" and "duplicate meals survey," to estimate the dietary intake of biotin in patients. As for hospital meals, the daily average biotin contents for 10 days calculated by the food group calculation survey were 19.4 μg/day in meals for infants, 45.5 μg/day in meals for children, 52.8 μg /day in meals for pregnant/lactating women, and 56.7 μg/day in common meals for adults. The average contents of biotin for 10 days by the duplicate meals survey were 9.7 μg/day in meals for infants, 41.6 μg/day in meals for children, 34.2 μg /day in meals for pregnant/lactating women and 41.9 μg/day in common meals for adults. The common meals contained basic and standard cooking ingredients and balanced with Dietary Reference Intake (DRI) for adult patients. The average intake of biotin in common meals for adults in the hospital exceeded the Adequate Intake (AI) (50 μg/day) for adults via the food group calculation survey, but was not sufficient in meals for adults and pregnant/lactating women by the duplicate meals survey. It is necessary to be careful about the kinds of foods and the method of cooking the ingredients when the biotin intake for hospital patients is calculated using the hospital menu sheet.

Introduction

Biotin is one of the water-soluble vitamins which are contained relatively rich in the liver and the egg yolk[1)]. This vitamin is associated with gluconeogenesis, amino acid metabolism, synthesis of fatty acid and energy production as a coenzyme of carboxylases in vivo[2)]. Biotin deficiency is rare in humans because biotin is widely distributed in various foods and is synthesized by the intestinal microflora. However, clinical signs such as dermatitis and hair loss appear when biotin becomes deficient. In the experimental animals, we found that the biotin deficiency during gestation induced congenital anomalies such as cleft palate and micrognathia in fetuses[3-5)]. Also, urinary biotin decreases in the later stages of gestation in pregnant women and mice[6)]. It was recently reported that biotin deficiency is related to atopic dermatitis[7)] and diabetes[8)], and the organic acid, 3-hydroxyisovaleric acid, is a sensitive biomarker of biotin deficiency[9)].

In Japan, the recommended intake of biotin was set to 30 μg/day in "Recommended Dietary Allowances-Dietary Reference Intakes (DRIs)-," in 2000[10)]. Afterwards, the Adequate Intake (AI) of biotin for adults was set to 45 μg/day and 50 μg/day in "Dietary Reference Intakes for Japanese, 2005 version" and "2010 version," respectively[11-13)]. On the other hand, the use of biotin for Foods with Nutrient Function Claims (FNFC) was authorized in 2003, and as a health claim, biotin was regulated as a nutrient which helps maintain healthy skin and mucosa[14)]. The upper and lower limits are 500 and 10 μg/day, respectively. However, this vitamin is not yet permitted as an additive in any food. As biotin was not listed in the Standard Tables of Food Composition in Japan, 5th revised edition (Japanese Food Composition Table) until 2005[15)], the biotin intake from meals or the requirement of biotin could not be estimated by diet surveys using the food composition table.

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However, the biotin contents of limited foods (only 498 foods) were recently added to the Japanese Food Composition Table in 2011[16].

The AI of biotin for healthy adults was set to 30 μg/day in the DRIs in 1998 in the U.S.A., which is different from that in Japan[17]. There are not many studies on the dietary intake of biotin in each country and a confirmed conclusion has not been obtained as yet. Also, evidence is limited on the nutritional state of micronutrients in hospital patients as well. The nutritional state frequently has serious problems in hospital and aged care settings. In hospitals, biotin deficiency is often induced by using total parenteral nutrition[18]. Biotin deficiency is induced in infants fed with special therapeutic infant formulas that are only in Japan[19].

Parenteral nutrition-associated biotin deficiency has not been reported since the vitamin was routinely added to parenteral nutrition[20]. However, marginal biotin status associated with diffuse hair loss could still be prevalent[21, 22]. Thus, it is not well-known whether the intake of biotin is filled to maintain the requirement for patients. Also the biotin content of all foods is not listed in Japanese Food Composition Table as yet. Therefore, we determined the biotin content in hospital meals using different dietary surveys such as "food group calculation survey" and "duplicate meals survey," to estimate the dietary intake of biotin in patients.

Materials and Methods

Meal sampling

Meals for patients in a hospital located in Himeji, Japan were nutritionally surveyed. Hospitals cater various kinds of meals for infants (aged 7 through 12 months), children, pregnant/lactating women, and adults. These meals were collected at breakfast, lunch and dinner, separately, for 10 days. A snack was also included in meals for children and pregnant/lactating women. The meal sampling periods were divided into two periods, from July 30 to August 10 and from August 21 to September 3, 2007. Total 120 meal samples were pretreated in accordance with the procedure manual set out in the Japanese Food Composition Table. After weighing meals and foods, all samples were homogenized into every meal and frozen at − 40 °C until shortly before use.

The biotin content of 500 foods and royal jelly was already determined in our previous studies and published on our website in English and Japanese[23]. The average content of biotin was calculated in 98 food groups according to the food categorization used in the Nation Health and Nutrition Survey (NHNS) in Japan (group average of biotin content)[24]. The foods determined were selected by considering the characteristics of their food groups and our dietary habits among the 1,878 foods listed in the Japanese Food Composition Table (2011)[16]. Also, the biotin content of 498 foods which are different from our 500 foods was newly listed in the Japanese Food Composition Table in 2011[16].

Food group calculation survey

Food group calculation is one of the diet surveys. This survey can be easily estimated, even the dietary intake of nutrients which are not listed in the food composition table, using a nutrient content of the limited foods determined. A dietary intake of biotin can be estimated using both the group average of biotin content and the food amount taken in food groups. So, based on the group averages of biotin content and the amount of the cooking ingredient classified in 98 food groups on the hospital menu sheet, daily intakes of biotin were estimated from the hospital meals for each day. As a comparative study, using the amount of foods taken in 98 food groups reported in the NHNS in Japan, 2011[24], the daily intake of biotin for Japanese adults (males and females) was estimated from common meals for adults.

Duplicate meals survey

The duplicate meals survey can also calculate the intake of micronutrients which are not listed in the Japanese Food Composition Table. Four different kinds of hospital meals for infants, children, pregnant/lactating women and adults were obtained for 10 consecutive days. The dietary intake of biotin was estimated by determining the content of biotin in these hospital meals. It was compared to the food group calculation surveys shown above.

Biochemical analysis

The biotin content in the meals was determined by the microbiological assay using *Lactobacillus plantarum* ATCC 8014. Biotin contained in meals and foods is generally in parts in protein-bound form. Therefore, protein-bound biotin was hydrolyzed before biotin determination. 100 μL of each sample were transferred into microtubes and 100 μL of 2.25 M H_2SO_4 were added. After samples were hydrolyzed by autoclaving for 60 min at 121 °C (2 atoms), they were neutralized by adding approximately 100 μL of 4.5 M NaOH. The supernatant was used as a sample for biotin determination after centrifuging at 10,000 rpm for 5 min. The biotin content was expressed as μg/100 g.

Table 1 Estimation of biotin intake by the food group calculation survey using 98 food groups

Food group classification			Biotin	Amount of	Biotin intake[f]	
Large classification[a]	Middle classification[b]	Small classification[c]	contents[d]	food intake[e]	males	females
Cerials	Rice-processed products	Rice	1.9	381.8	7.4	5.1
		Rice products	1.7	4.3	0.1	0.1
	Wheat-processed products	Wheat	1.8	3.8	0.1	0.1
		Bread	2.4	31.3	0.8	1.1
		Sweet buns	2.9	6.1	0.2	0.1
		Japnese noodles	1.2	46.5	0.5	0.5
		Precooked noodles	1.4	5.8	0.1	0.1
		Macaroni and spaghetti	2.7	9.3	0.3	0.3
		Other wheat products	3.2	5.7	0.2	0.1
	Other cereal-processed products	Buckwheat noodles and their products	2.5	7.9	0.2	0.2
		Corn and its products	2.5	0.5	0.0	0.0
		Others	4.7	1.3	0.1	0.1
Potatoes and Starches	Potato-processed products	Sweet potatoes and their products	3.5	5.4	0.2	0.3
		Potatoes and their products	1.2	29.3	0.3	0.3
		Others	1.5	17.6	0.3	0.3
	Starch-processed products	Starches and their products	0.9	2.5	0.0	0.0
Sugars and Sweetneners	Sugars and Sweetneners	Sugars and Sweetneners	3.1	6.4	0.2	0.2
Pulses	Soybeans-processed products	Whole soybeans and their products	19.3	1.2	0.2	0.3
		Tofu	7.5	33.6	2.5	2.1
		Abura-age[g]	3.9	7.9	0.3	0.3
		Natto	11.7	5.5	0.6	0.6
		Other soybean products	8.3	3.7	0.3	0.5
	Other pulses-processed	Others	9.0	1.3	0.1	0.2
Nuts and Seeds	Nuts and Seeds	Nuts and Seeds	22.5	2.0	0.5	0.3
Vegetables	Green and yellow vegetables	Tomatoes	1.7	13.9	0.2	0.2
		Carrots	1.9	19.4	0.4	0.5
		Spinach	3.3	16.7	0.6	0.5
		Sweet peppers	1.3	4.0	0.1	0.0
		Other green and yellow vegetables	5.3	31.4	1.7	1.9
	Other vegetables	Cabbages	1.8	23.8	0.4	0.4
		Cucumbers	1.9	9.8	0.2	0.2
		Daikon[h] (Japanese radishes)	0.7	30.0	0.2	0.1
		Onions	1.2	33.4	0.4	0.3
		Chinese cabbage	2.1	21.2	0.4	0.4
		Other vegetables	2.6	45.5	1.2	1.0
	Vegetable juce	Vegetable juce	2.7	10.9	0.3	0.2
	Pickles	Pickles	0.5	3.9	0.0	0.0
		Takuan-zuke[i] and others	0.8	8.3	0.1	0.1
Fruits	Raw fruits	Strawberries	2.2	0.1	0.0	0.0
		Citrous fruits	0.7	18.6	0.1	0.2
		Bananas	2.5	14.6	0.4	0.4
		Apples	1.6	16.9	0.3	0.3
		Others	1.3	29.9	0.4	0.6
	Jam	Jam	0.5	1.0	0.0	0.0
	Fruit juices	Juice	0.7	13.6	0.1	0.1
Mushrooms	Mushrooms	Mushrooms	9.3	15.0	1.4	1.4
Algae	Algae	Algae	5.1	10.5	0.5	0.6
Fishes and Shellfishes	Raw fishes and shellfishes	Horse mackerels and sardines	3.9	10.9	0.4	0.4
		Salmons	8.1	4.2	0.3	0.3
		Righteye flounders and sea breams	11.3	6.6	0.7	0.2
		Tunas	2.6	5.4	0.1	0.1
		Other fishes	3.1	9.2	0.3	0.7
		Shellfishes	9.1	2.8	0.3	0.2
		Cuttlefishes	3.9	5.2	0.2	0.1
		Prawns, shrimps and crabs	2.4	6.0	0.1	0.1
	Fishes and shellfishes-products	Dried products	10.6	16.2	1.7	1.4
		Canned products	8.0	2.3	0.2	0.1
		Tsukudani[j]	12.8	0.2	0.0	0.0
		Fish paste products	1.1	11.3	0.1	0.1
		Fish hams and sausage	1.8	0.7	0.0	0.0
Meats	Animal meats	Beef	1.2	17.0	0.2	0.1
		Pork	2.1	36.9	0.8	0.6
		Hams and sausages	3.9	14.8	0.6	0.5
		Other animal meat	—	0.2	—	—
	Poultries	Poultries	2.4	26.4	0.6	0.5
		Other poultries	—	0.1	—	—
	Offal meats	Offal meats	26.1	1.7	0.4	1.4
	Other meats	Whale meats	—	0.0	—	—
		Other meats and their products	—	0.0	—	—

Eggs	Eggs	Eggs	17.9	37.6	6.7	5.8
Milks	Milk and dairy products	Milks	3.1	88.9	2.7	2.7
		Cheeses	2.6	2.4	0.1	0.1
		Fermented milks and lactobacillus beverages	1.4	20.9	0.3	0.5
		Others	1.7	9.2	0.2	0.1
	Other milks	Other milks	—	0.3	—	—
Fats and Oils	Fats and Oils	Butters	0.6	1.0	0.0	0.0
		Margarines	0.1	1.1	0.0	0.0
		Vegetable fats and oils	0.0	9.0	0.0	0.0
		Animal fats	0.0	0.2	—	—
		Others	—	0.0	—	—
Confectioneries	Confectioneries	Traditional confectioneries	1.7	9.7	0.2	0.2
		Cakes, buns and pastries	4.9	5.8	0.3	0.4
		Biscuits	1.2	1.4	0.0	0.0
		Candies	1.3	0.3	0.0	0.0
		Others	3.8	5.5	0.2	0.3
Beverages	Alcoholic beverages	*Sake*	0.0	15.5	—	—
		Beers	1.0	98.0	1.0	0.2
		Others	0.4	52.4	0.2	0.0
	Other beverages	Teas	0.4	276.0	1.2	1.9
		Coffees and cocoas	2.1	123.4	2.6	1.1
		Others	0.2	128.4	0.2	0.3
Seasonings and Spices	Seasonings	Suauces	5.7	2.0	0.1	0.1
		Syoyu[k]	12.7	15.8	2.0	1.6
		Edible salts	0.0	1.5	—	—
		Mayonnaise	0.5	3.2	0.0	0.0
		Miso[l]	9.4	10.9	1.0	1.4
		Others	1.5	64.8	1.0	1.2
	Spices	Spices and others	20.9	0.3	0.1	0.1
Prepared Foods	—	—	—	13.6	—	—
Total		all ages			52.0	45.6
		children ages 1-2 years old			27.3	24.0
		children ages 8-9 years old			42.8	41.5
		children ages 10-11 years old			46.6	43.4
		adults ages 18-29 years old			48.7	39.2

[a]17 food group
[b]33 food group
[c]98 food group
[d]μg/100 g
[e]For males in The National Health and Nutrition Survey (2011) (g/day)
[f]μg/day
[g]Fried thin slices of pressed *tofu*
[h]Japanese radishes
[i]Pickled with rice bran and salt
[j]Simmered in soy sauce and suger
[k]Soy sauce
[l]Fermented soybean
Itaric: Japanese food name (If there are not English name)

Statistical analysis

Values are mean ± SD. The Spearman's rank correlation test was used to compare the relationship in dietary intake of biotin between the food group calculation survey using the group average of biotin content and the duplicate meals survey. Statistical analysis of these data was performed using Statcel 2 (OMS Publishing, Saitama, Japan). Differences were considered significant as a probability level of $p < 0.05$ in all analysis.

Results

Daily intakes of biotin by the food group calculation survey

1) Biotin contents of foods

Other than royal jelly, 500 foods were classified into 98 food groups (the small classification) according to the categorization of the Japanese Food Composition Table[16] (Table 1). A group average of biotin content was calculated in 98 food groups. In this group average, the biotin content of meats (offal meats) was 26.1 μg/100 g, which was highest in the small classification, but the biotin content of vegetable fats and oils, Sake and edible salt was under the detectable limit.

2) Biotin intakes from meals surveyed in NHNS

The estimated daily intakes of biotin in males were 52.0 μg for all ages, 27.3 μg for children ages 1-2 years, 42.8 μg for children ages 8-9, and 48.7 μg for adults ages 18-29 from average biotin contents and food intakes of 98 food groups in the NHNS 2011 (Table 1). In females,

Table 2 Representative menu for children in the hospital

Meals	Dishes	Foods	Volume[a]	Biotin contents[b]	Biotin intake[c]
Breakfast	Bread	Mitsuami bread	70	2.9	2.0
	Milk	Milk	100	3.1	3.1
	Boiled egg	Egg	50	17.9	9.0
	Fruit	Orange	40	0.8	0.3
Lunch	Rice	Rice	130	1.9	2.5
	Hamburg steak	Hamburg steak	60	1.2	0.7
		Oil	2	0.0	0.0
	Aurora sauce	Soft flour	3	1.7	0.1
		Margarine	3	0.1	0.0
		Ketchup	15	2.5	0.4
		Mushrooms, canned	7	9.8	0.7
	Boiled vegetables	Young sweet corn, frozen	30	2.2	0.7
	Spaghetti	Spaghetti, dried	12	2.7	0.3
		Parsley	1	5.4	0.1
		Oil	2	0.0	0.0
	Salad	Cabbage	35	1.9	0.7
		Radish	7	2.2	0.2
		Cucumber	15	1.9	0.3
		French sauce, white	7	2.5	0.2
	Green potage	Green peas	15	2.2	0.3
		Potage sauce	7	2.2	0.2
		Milk	12	3.1	0.4
	Fruit	Delaware	40	1.5	0.6
	Milk	Milk	200	3.1	6.2
Snack	Almond jelly	Almond jelly sauce	10	1.5	0.2
		Milk	15	3.1	0.5
		Peach, canned	10	1.5	0.2
		Cherry, canned	5	1.5	0.1
Dinner	Rice ball	Rice	130	1.9	2.5
		Umechirimen	2	4.6	0.1
	Fish boiled in broth	Fish	60	6.6[d]	4.0
		Daikon	50	0.2	0.1
	Ohitashi	Spinach	50	3.3	1.7
		Sesame	1	15.4	0.2
	Kentinjiru	Tofu	15	7.5	1.1
		Burdock	5	2.2	0.1
		Daikon	10	0.2	0.0
		Carrot	5	2.8	0.1
		Shiitake mushroom	5	9.8	0.5
		Welsh onions	2	5.4	0.1
		Sayaingen, frozen	2	2.2	0.0
	Fruit	Grapefruit	80	0.8	0.6
		Cherry, canned	5	1.5	0.1
		Suger	3	3.1	0.1
	Milk	Milk	200	3.1	6.2
			1528	—	47.0

[a] g
[b] μg/100 g
[c] μg
[d] The average of the group of Fish and Shellfishes in 17 food groups.

45.6 μg for all, 24.0 μg for children ages 1-2, 41.5 μg for children ages 8-9, 39.2 μg for adults, respectively.

The highest intake of biotin in men and women was 7.4 μg/day and 5.1 μg/day in rice, and was subsequently 6.7 μg/day and 5.8 μg/day in eggs, 2.7 μg/day and 2.7 μg/day in milk which were contributed 14.2% and 11.2% , 12.9% and 12.7% and 5.2% and 5.9% in daily total biotin intake, respectively. On the other hand, fats and oils such as vegetable oil did not contribute to the biotin intake at all.

3) Biotin intakes from meals shown in the hospital menu

As for hospital meals, the daily average biotin intakes for 10 days calculated from the group average biotin and the amounts of the cooking ingredients shown on the hospital menu sheets were 19.4 μg/day in meals for infants, 45.5 μg/day in meals for children, 52.8 μg /day in meals for pregnant/lactating women, and 56.7 μg/day in common meals for adults (Table 2) (Fig. 1). There was a large variation in daily biotin intakes in children by the kinds of

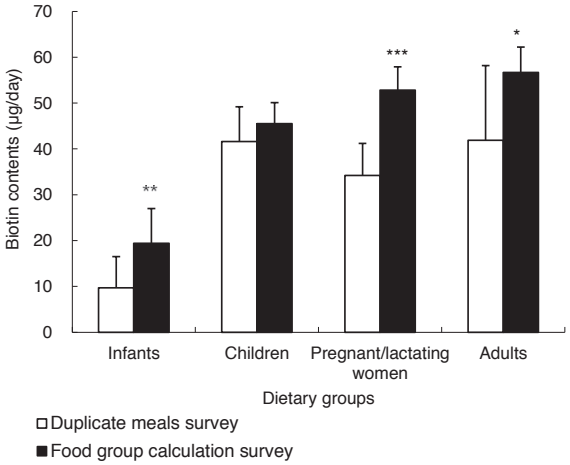

Fig. 1 Comparison of average biotin contents from hospital meals by the food group calculation survey and the duplicate meals survey.
Values are means ± SD, n = 10
Student's t test, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

cooking ingredients (Fig. 2a).

Daily intakes of biotin by the duplicate meals survey

1) Biotin intakes from meals in the hospital

The average biotin intakes for 10 days by the duplicate meals survey were 9.7 μg/day in meals for infants, 41.6 μg/day in meals for children, 34.2 μg/day in meals for pregnant/lactating women and 41.9 μg/day in common meals for adults. These meals contained basic and standard cooking ingredients but did not balance with the DRI for both adult patients and for pregnant/lactating women (Fig. 1). The daily biotin intakes in infants, children, pregnant/lactating women and adults varied greatly during 10 days (Fig. 2b).

2) Correlation between the food group calculation and duplicate surveys

There was a correlation in biotin contents of hospital meals between the food group calculation and duplicate meals surveys (Fig. 3). Both data were fitted to a smooth curve in regression analysis ($r = 0.89$, $P < 0.01$). The biotin contents of these meals determined by the duplicate meals survey was mainly lower than that calculated by the food group calculation survey. The difference between both surveys was especially large in hospital meals for children, pregnant/lactating women and adults. These hospital meals contained a large amount of eggs and milk.

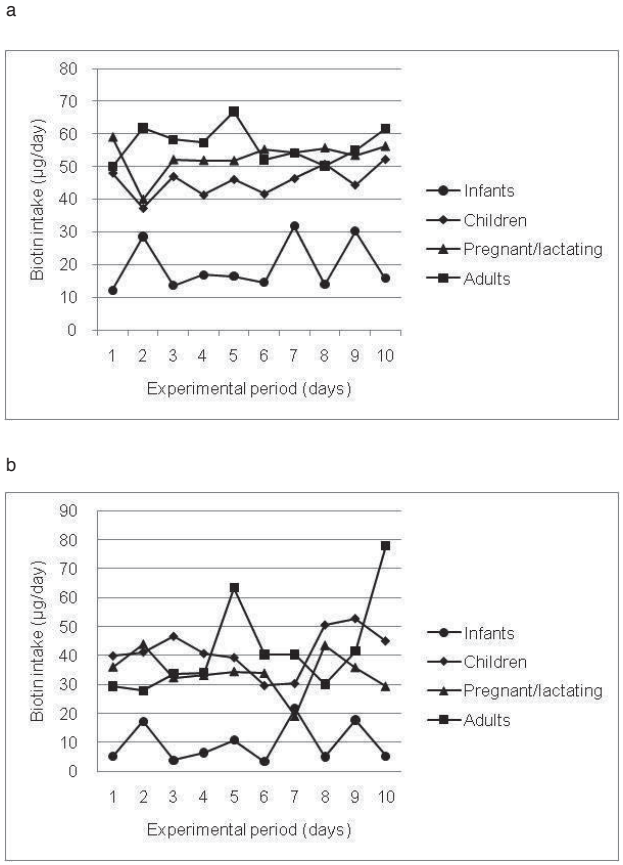

Fig. 2 Change of daily intake of biotin from hospital meals estimated by the food group calculation survey and the duplicate meals survey for 10 consecutive days.
a, Food group calculation survey. b, Duplicate meals survey.

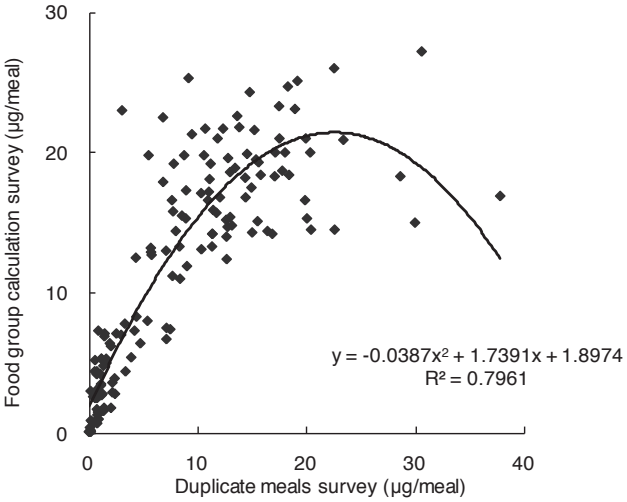

Fig. 3 Correlation in biotin contents of hospital meals between the food group calculation survey and the duplicate meals survey.

Discussion

The average intake of biotin in men was 52.0 μg/day (45.6 ug/day in women) for all ages by the food group calculation survey (98 food groups) in Japan. These values were as close as 50 μg/day of AI for adults in DRIs for Japanese (2010 version)[12]. On the other hand, the dietary intake of biotin in the hospital meals estimated by the food group calculation survey was 56.7 μg/day, on average for adults, which was higher than 41.9 μg/day by the duplicate meals survey. Also, the estimation of dietary biotin intake for other hospital meals tended to be low in the du-

plicate meals survey. The biotin intake by the food group calculation survey exceeded the AI for all ages, but only exceeded the AI in children by the duplicate meals survey. This is because foods determined by the food group calculation survey are not cooked completely, which means there are raw food materials. It is suggested that biotin may be lost via cooking in hospital meals which was determined by the duplicate meals survey in this study.

Also, if there is a large variation in biotin content within the food group, it seems to cause a difference in biotin intake between both dietary surveys. For example, livers where the biotin content is high raises the mean of the food group "Pork"[16], and biotin intake rises in an appearance by the food group calculation survey when a lot of pork classified in the same food group is eaten. The number of foods used in this study is 500, which is only 27.0% of the 1,878 foods listed in the Japanese Food Composition Table. To increase the accuracy of estimation of biotin intake, the remaining foods, especially cooked and processed foods, should be determined.

The AI of biotin set in DRIs for Japanese (2010)[12] is 4 μg/day for infants ages 0 through 5 months and 10 μg/day for infants ages 6 through 11 months, which in US-DRIs is 5 μg/day for infants ages 0 through 6 months and 6 μg/day for infants ages 7 through 12 months[17]. The biotin contents of infant meals in the hospitals in this study were 19.4 μg/day in the food group calculation survey, which exceeded the AI for infants ages 6 through 11 months, and the biotin content by the duplicate meals survey was 9.7 μg/day which was close to the AI for infants ages 6 through 11 months. As the number of foods in the meals catered in the hospitals is low for infants, the biotin intake largely depends on the kind of foods. The biotin content becomes high in the meals containing liver or egg yolk[1]. This may be also related to the daily variation of biotin content in the infant meals (CV = 69.8 in the duplicate meals survey; CV = 39.3 in the food group calculation survey).

The AI of biotin intake in DRIs for Japanese people is 20 μg/day for children ages 1 through 2 years and 25 μg/day for children ages 3 through 5 years[12], which in US-DRIs is 8 μg/day for children ages 1 through 3 years and 12 μg/day for children ages 4 through 8 years[17]. The meals for children contain high contents of biotin, which are 45.5 μg/day in the food group calculation survey and 41.6 μg/day in the duplicate meals survey. The biotin contents in these meals by both diet surveys exceeded the AI. The reason why the biotin content of children meals is high may be because milk is contained in hospital meals. Fresh milk is especially served to children twice every day. By the food group calculation survey, the biotin intake from two cups of milk (400 mL) is 12.4 μg, and the contribution is 27.3% in the total intake of biotin. Therefore, it is thought that the use of milk in the meals is a useful way to get biotin in infants and children in hospitals.

The AI of biotin is 50 μg/day for adults in Japan[12] and 30 μg/day in US[17]. The food group calculation survey showed 56.7 μg/day in the biotin amount of the common meals. On the other hand, the duplicate meal survey was 41.9 μg/day, which is markedly lower than that by the food group calculation survey. The biotin amount per common meal for adults ranged from 27.4 to 78.0 μg/day with a large difference (Fig. 2b). Eggs (17.9 μg/100 g) are commonly included in hospital meals, which largely contribute to the biotin intake as well (12.9% in male adults).

The additional amount of 2 μg/day is set for pregnant women[12], and the AI in Japan[12] and US[17] is 52 and 30 μg/day for pregnant women, respectively. The biotin amount in meals for pregnant/lactating women was 52.8 μg/day by the food group calculation survey. On the other hand, the duplicate meals survey showed 34.2 μg/day. The kind of foods in meals for pregnant/lactating women is similar to infant meals in this hospital menu, but fresh milk is not included in these meals. A large variability of biotin intake between days was not seen in meals for pregnant/lactating women. It is suggested that a device to increase biotin intake from meals is necessary for these women.

The comparison of biotin intakes reported in other countries is shown in Table 3[25-37]. In the early studies, Hoppner et al.[25] first reported that the biotin intake in the common meals in Canada was 62 μg/day in the calculated value and 60 μg/day in the analyzed value. Lewis and Buss[28] demonstrated that the average daily intake of biotin was 35 μg/day (37.5 μg/day including alcoholic drinks and confectionery) in 6,925 households surveyed in England. Afterwards, several studies demonstrated that biotin intake ranged from 25-35 μg/day in different of countries and dietary surveys. In studies over the past 10 years, authors[31] have reported that the biotin intake ranged from 29.8-33.3 μg/day in the middle and old ages in the Tohoku district of Japan in the duplicate meals survey. Also, the biotin intake ranges from 40-50 μg/day for adults by the duplicate meals survey and also by the total diet study (TDS)[32, 35, 36]. On the other hand, the biotin intake ranged from 50-60 μg/day for adults by the food group calculation survey[36], which is higher than the duplicate meals and TDS surveys. Taking into consideration the result of two kinds of dietary surveys, it is thought that the variability

Table 3 Comparison of the dietary intake of biotin

References	Daily intake	Subjects	Notes
Hoppner et al. 1978[25]	62	Canadaca	calculation of composite diet
	60		analysis
Bull & Buss 1982[26]	35.5	7,277 housewives	calculation by the National Food Survey, 1979
Murphy & Calloway 1986[27]	39.9 ± 26.9[a]	996 women (18-24 years old, USA)	24-hour recall (NHANES II)
Lewis & Buss 1988[28]	35	6,925 households	calculation by the National Food Survey, 1986
Bliss et al. 2000[29]	32 ± 12[a]	32 subjects (25-85 years old, USA)	diet record for consecutive days
Iyengar et al. 2000[30]	35.5 ± 7.5[a]	USA	total diet composites (FDA-TDS)
Watanabe et al. 2004[31]	29.8-33.3	adults in Tohoku district, Japan	duplicate meals
Saitoh & Ushio 2004[32]	45.1	Tokyo, Japan	TDS (13 food groups)
Taniguchi et al. 2005[33]	109.8	men	food group calculation survey (18 food groups, 100 foods)
	92.3	women	
Watanabe & Taniguchi 2006[34]	60.7	Tokyo, Japan	Re-analysis TDS (13 food groups)
Murakami et al. 2008[35]	70.1	Osaka City, Japan	TDS (13 food groups)
Watanabe & Taniguchi 2009[36]	51.1	all ages	TDS (18 food groups), 2005
	54.5		food group calculation survey (98 food groups, 330 foods)
Watanabe et al. 2010[37]	51.0	all ages	TDS (18 food groups), 2006
	52.4	adults ages 24 years and older	
Present study	9.7[b] / 19.4[c]	infants (baby foods)	Hospital meals
	41.6 / 45.5	children	
	34.2 / 52.8	pregnant/lactating women	
	41.9 / 56.7	adults	
	27.3[c, d] / 24.0[c, e]	children ages 1-2 years old	NHNS[f]
	42.8 / 41.5	children ages 8-9 years old	
	46.6 / 43.4	children ages 10-11 years old	
	48.7 / 39.2	adults ages 18-29 years old	
	52.0 / 45.6	all ages	

[a] mean ± SD
[b] duplicate meals survey
[c] food group calculation survey (98 food groups, 500 foods)
[d] males
[e] females
[f] 8,762 subjects (except infants)

of biotin intake in these studies is caused by difference in dietary survey, cooking loss, investigated country, and age distribution of population.

From these findings, it is demonstrated that the food group calculation survey is a useful method for the dietary intake of biotin. The merit of this survey makes it possible to easily calculate the dietary intake of biotin and to utilize the estimated dietary intake of biotin not listed in the Japanese Food Composition Table[16]. The average intake of biotin in common meals for adults in the hospital is appropriate at 50 μg/day by the food group calculation survey, which is overestimated compared to that (the real intake) determined by the duplicate meals survey. It is necessary to be careful about the kinds of foods and the method of cooking the ingredients when the biotin intake for hospital patients is calculated using the hospital menu sheets.

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