NUTRITIONAL SURVEY INCLUDING NITROGEN BALANCE STUDIES OF NORMAL JAPANESE CHILDREN RECEIVING ROUTINE DIET (3–17 YEARS OLD)

Setsuko SANTO

Laboratory of Home Economics, Department of Agricultural Chemistry,
Faculty of Agriculture, Hokkaido University,
Kita-ku, Sapporo 060, Japan

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Summary

The nitrogen (N) balance studies of 142 normal and healthy children (94 males and 48 females) aged 3–17 years have been conducted from 1983 to 1984. These subjects were members among 464 children who had taken routine diets supplied with 13 : 31 : 56 of mean protein-fat-carbohydrate (PFC) energy ratio in 6 orphanages in Hokkaido, the northernmost and second largest island of Japan. Duration of balance stidues was 72 hours. The results (M±SE) of 142 subjects are shown as follows : height (cm) 140.4±1.3, weight (kg) 36.2±0.9, energy intake (kcal/kg/day) 69±2, N intake (mg/kg/day) 384±7, digestibility (%) 85.5±0.4, apparent N retention (mg/kg/day) 65±5, apparent N retention % of the intake 16.2±1.1, regression of N retention on N intake $Y=0.359X-73.0$, $r=0.52$ ($p<0.01$) (Y: N retention, X: N itake, both in mg/kg/day). For 94 boys, $Y=0.431X-105.6$, $r=0.62$ ($p<0.01$) with 74±2 kcal/kg/day in energy intake was obtained. Both the N intake of routine diet and the urinary N excretion were about 4 times of those based on an egg and a milk formulae for infants by HUANG. The apparent obligatory N excretion for the entire group, 73 mg/kg/day, showed similar results of the values reported by HUANG and 1973 FAO/WHO. The apparent N maintenance requirement, 203 mg/kg/day, was almost twice of the value of adult men fed a customary diet in Japan. The ratio of N maintenance requirement to obligatory N excretion, 2.9, was rather close to the values of an egg diet and a customary one for the adult men in Japan.

Key Words Nutrition survey, nitrogen balance study, normal and healthy Japanese children, routine diet.

The Recommended Dietary Allowances for Japanese (JRDA) was revised in 1984 (1), and the JRDA Committee showed allowances on 11 items.

The JRDA Committee on Protein stated the basic fact which was similar to that reported in the 1979 revision (2). It has been found that few experimental data on N balance of growing children above one-year-old have been available. In the case of estimating protein intake based on N accumulation calculated by yearly amount of growth information, the utilization of intake N for N accumulation has been found to be missing. Therefore, according to the JRDA Committee, the protein allowance per kilogram of body weight was based on 2.9 g for a 1-year-old, 1.2 g for a 20-year-old, and the values of gradual decrease between the two ages as they grew older. Results of nutritional survey by INOUE *et al.* (3) and KOISHI *et al.* (4) were used to estimate the decreasing values as a base (1).

The purpose of this study is to investigate N balance for normal and healthy children on a routine diet in Japan.

Methods

Subjects:

Four hundred and sixty four normal and healthy children from broken homes cared for at 6 social welfare institutions in Hokkaido are subjects called orphanage children in this study. Their ages ranged 3–17 years. They consisted of 272 males and 192 females, and their average stay in these institutions has been 3 years and 6 months. Their average measurements by sex and age in height, weight, sitting height, and chest circumference have not shown significant differences compared to those of national averages. Among them, 142 children were chosen as subjects for N balance study. The survey lasted for 3 consecutive days during vacation periods from August 1983 to August 1984. During the survey, daily activities were allowed as usual except that children could not go far away.

Procedures:

1. Anthropometric measurements included height, weight, sitting height, chest circumference, head circumference, upper arm circumference, and skinfold thicknesses (triceps and subscapular).

2. Weighing of food was done in the kitchen, before and after preparation, and also in the dining room when eaten by each child (leftovers were subtracted).

3. Collecting samples for analyses was carried out with separate samples of all food eaten by children in the dining room for 3 days, 24-hour urine

specimen for 3-day experimental period, and fecal specimens depending on the food eaten during the survey period using carmine as the marker, actually, it required 5–9 days to obtain fecal specimens.

4. Sample preparations for analyses were as follows: a) each food sample and each fecal specimen was homogenized, dried in a forced-draft oven at 80°C and ground. Before drying, the surface of a fecal specimen was covered with enough 2N H_2SO_4 to prevent vapouring of NH_3. b) urine was collected under H_2SO_4 acidic condition from each individual, and 1/20 of each specimen was stocked in a freezer until analysis was done.

5. Analytical method of total nitrogen was performed by semi-micro Kjeldahl method for NH_4-N only with a Kjeltec system of Tecator Co. Ltd. which was constitued of a decomposing and distillating instrument.

6. Energy and nutrient intakes were calculated using the amount of food actually consumed by each child and food composition tables (6, 7) except for fiber (8) and for vitamin D (9). Nutrient adequacy was obtained as the ratio of amount of nutrient supplied to the JRDA.

7. Analytical N intake was obtained by the quantity of each food consumed and the value by analysis in my laboratory. N absorption is the value that the N intake minus fecal N excretion, and N digestibility is the percentage of the N absorption divided by the N intake. N retention is the value that the N absorption minus urinary N excretion.

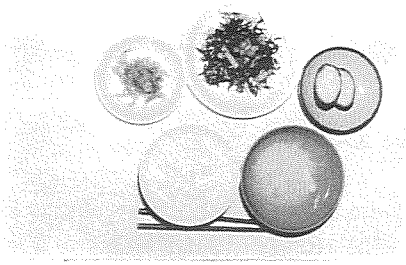
The multi-processing system, HITAC M-280H, M-280H and M-200H, at the Computer Center of Hokkaido University was used.

Results

Figs 1–2 show an example of a routine diet consisting of 16 pictures describing food items, meals and snacks served to children on one day at an institution as well as preparation of meals, dining room scenes, and children's daily activities. Situations have been similar in the other 5 institutions.

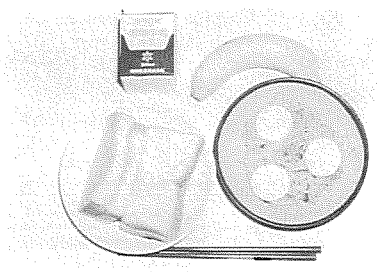
Table 1 indicates the mean value of 464 children among 6 institutions relating to nutrient intake by food group and the nutrient adequacies. The nutrient intake was considered without preparation losses. Concerning phosphorus (P), sodium (Na), and potassium (K), 1200 mg for P, 3932 mg for Na, and 2000 mg for K are shown as dietary goals for Japanese except for 11 items of JRDA (1). The maximum nutrient adequacy for thiamine (VB_1) is 2.6 (53% from enriched rice and 20% from meat and poultry) according to Tables 1 and 2. Without regard for preparation loss, it seems reasonable that a lower additing percentage of enriched rice to polished rice could be sufficient. Point of interest included 1.6 of Na which suggested a group

Breakfast food items



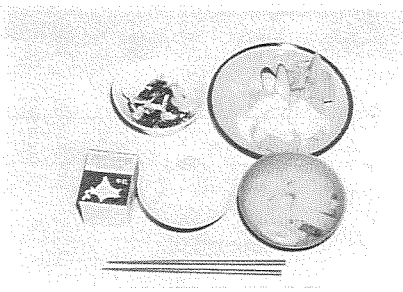
A child's breakfast

Lunch food items

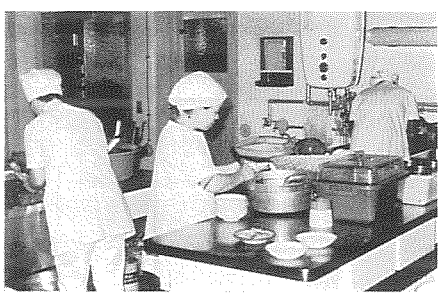


A child's lunch

Supper food items



A child's supper



Meal preparation

Snacks

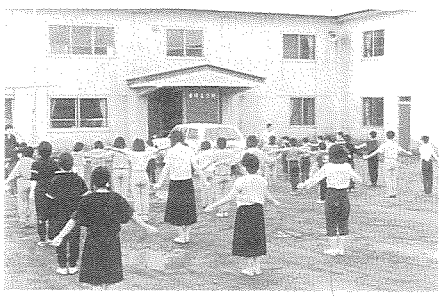
Fig. 1. An example of a routine diet served an orphanage during this survey period, and kitchen scene for preparation of meals.

Washing hands before meals
(using medicinal soap)

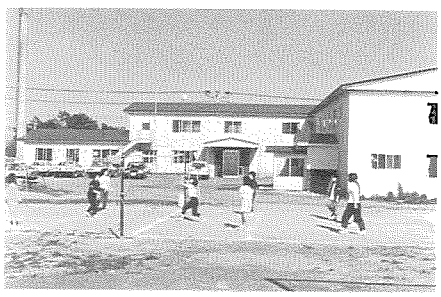
Preschoolers at supper

Girls at supper

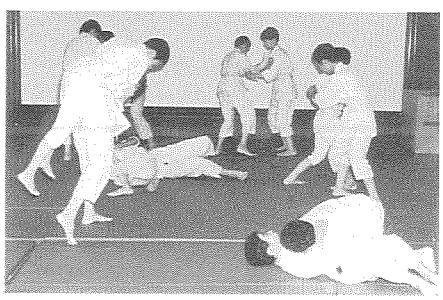
Boys at supper



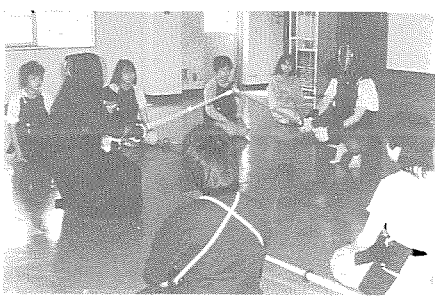
Morning exercises before breakfast



Older girls playing volleyball



Boys practicing Judo



Boys & girls practicing Kendo

Fig. 2. Dining room scenes and childrens' daily activities at an orphanage in Hokkaido in 1984.

TABLE 1. Average nutrient intake from food group for 464 children at 6 orphanages in Hokkaido in 1983–1984.

Food groups	Amount (g)	Energy (kcal)	Protein (g)	Fat (g)	NF (g)	DF (g)	Ca (mg)	P (mg)	Fe (mg)	Na (mg)	K (mg)	VA (IU)	VB_1 (mg)	VB_2 (mg)	Niacin (mg)	VC (mg)	VD (IU)
Grains	291	912	20.0	5.1	187.9	5.6	32	339	1.8	250	304	17	1.15	0.11	3.6	0	0
Potatoes	63	104	1.3	3.2	17.4	1.8	10	35	0.4	38	328	0	0.07	0.02	1.1	14	0
Sugar	7	28	0.0	0.0	7.3	0.0	0	0	0.0	0	0	0	0.00	0.00	0.0	0	0
Confectionery	57	236	3.9	8.2	36.5	0.8	20	37	0.3	117	48	50	0.03	0.04	0.2	0	0
Fats & Oils	17	150	0.0	16.3	0.0	0.0	0	0	0.0	9	0	67	0.00	0.00	0.0	0	0
Nuts	1	4	0.1	0.2	0.4	0.1	4	2	0.0	0	2	0	0.00	0.00	0.0	0	0
Legumes	56	95	6.2	4.5	6.7	0.6	72	82	1.6	984	152	0	0.04	0.05	0.4	0	0
Fish, Shellfish	47	62	8.1	1.6	3.1	0.0	46	97	0.7	493	121	10	0.04	0.09	1.4	0	48
Meat, Poultry	88	213	13.8	15.7	1.7	0.0	6	119	1.0	166	186	42	0.44	0.17	4.2	7	0
Egg, Roes	51	83	6.3	5.7	0.5	0.0	28	102	0.9	66	61	326	0.04	0.24	0.1	0	5
Milk	276	196	8.8	10.3	16.7	0.0	288	273	0.2	187	349	348	0.08	0.42	0.3	1	0
Vegetables	203	54	2.9	0.3	10.7	3.4	64	69	1.5	222	551	1194	0.11	0.11	0.8	45	0
Fruits	140	83	0.9	0.2	21.0	2.2	13	17	0.3	47	217	75	0.06	0.04	0.4	21	0
Fungi	6	0	0.4	0.1	1.0	0.2	0	7	0.1	27	38	0	0.01	0.03	0.4	0	0
Seaweeds	11	0	1.4	0.1	2.5	0.1	26	24	0.9	404	101	339	0.03	0.09	0.3	2	0
Beverage	29	23	0.3	0.1	4.9	0.0	1	4	0.1	2	10	0	0.00	0.00	0.0	2	0
Seasonings	56	113	2.2	8.3	8.6	0.1	16	38	1.0	3235	147	29	0.04	0.05	0.4	0	0
Total	1394	2340	75.8	79.5	325.7	15.0	626	1237	10.9	6237	2605	2494	2.16	1.48	13.5	90	53
Nutrient Adequacy		1.1	1.1				1.0	1.0	1.1	1.6	1.3	1.7	2.6	1.3	1.0	2.0	0.5

NF: Non-fibrous carbohydrate, DF: Dietary fiber, Ca: Calcium, P: Phosphorus, Fe: Iron, Na: Sodium, K: Potassium, VA: Retinol potency, VB_1: Thiamin, VB_2: Riboflavin, VC: Ascorbic acid, VD: Vitamin D.

carving salt, and 67% of Na was derived from salt, shoyu and miso. Energy ratio of starchy food (grains, potatoes and confectionery) was 53%. Animal protein ratio was 48%. Energy and protein necessary for N balance were 1.1 as the adequacies. Among 13 items of the nutrient adequacies, shortage of vitamin D, 0.5, was evident (90% of vitamin D came from fish) in the routine diet. So, part of meat consumption should be replaced by fish. According to Table 1, PFC energy ratios were calculated as 13 : 31 : 56. Table 2 shows that animal food consumption indicated high percentages of nutrients in the routine diet.

According to Table 3 showing anthropometric data of the 142 subjects, 3-17 years, for N balance studies, these subjects ranged mostly in boys of ages 10-14 years. The results (M±SE) were 140.4±1.3 cm in height, 36.2±0.9 kg in weight, 76.0±0.6 cm in sitting height, 68.3±0.6 cm in chest circumference, 53.2±0.2 cm in head circumference, 21.6±0.2 cm in upper arm circumference, 12.9±0.4 mm in triceps skinfold thickness, and 10.6±0.5 mm in subscapular skinfold thickness.

Summary of results of N balance studies of these subjects is shown in Table 4. Average value of 142 children revealed 384±7 mg/kg/day in N intake, 65±5 mg/kg/day in N retention, and 16.2±1.1% in N retention % of the intake. All data described above were based on analytical value, whereas, 69±2 kcal/kg/day in energy intake and 363±6 mg/kg/day in N intake were the values calculated by referring to food composition tables. Thus, the ratio of analytical value divided by calculated one in N intake was 1.06. Apparent absorption % of the intake (digestibility) was obtained as 86 which was not shown in table 4, but was in Table 5 as mean of D.

Fig. 3 shows daily N retention (Y) in relation to daily N intake (X) based on analytical value in 142 children. Black and white dots represent boy and girl respectively. The apparent N retention ranged from −36 to 235 mg/kg/day, with 65 mg/kg/day of mean, and for the N retention % of N intake, the range was from −12 to 58% and 16% of mean. The N intake ranged from 242 to 658 mg/kg/day, with 384 mg/kg/day as mean. The daily protein intake covered a range from 32.1 to 129.1 g with average of 83.5 g, in other words, from 1.5 to 4.1 g/kg with 2.4 g/kg of mean for the subjects. The regression formula for boys was $Y=0.431X-105.6$, $r=0.62$ ($p<0.01$), for girls $Y=0.236X-23.9$, $r=0.28$ (no significance), and for entire group $Y=0.359X-73.0$, $r=0.52$ ($p<0.01$) were obtained. Therefore, it appeared that the apparent net protein utilization (NPU) for boys was considered 43.1%, the N loss (urinary and fecal;) was 105.6 mg/kg, and mean N maintenance requirement of the routine diet was 245 mg/kg. For the

TABLE 2. Percentage of average nutrient intake from food group for 464 children at 6 orphanages in Hokkaido in 1983–1984.

Food groups	Amount	Energy	Protein	Fat	NF	DF	Ca	P	Fe	Na	K	VA	VB_1	VB_2	Niacin	VC	VD
Grains	21	39	26	6	58	37	5	27	16	4	12	1	53	7	26	0	0
Potatoes	4	4	2	4	5	12	2	3	4	1	13	0	3	2	8	15	0
Sugar	1	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Confectionery	4	10	5	11	11	5	3	3	3	2	2	2	1	2	1	0	0
Fats & Oils	1	6	0	20	0	0	0	0	0	0	0	3	0	0	0	0	0
Nuts	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Legumes	4	4	8	6	2	4	11	7	15	16	6	0	2	4	3	0	0
Fish, Shellfish	3	3	10	2	1	0	7	8	7	8	5	0	2	6	11	0	90
Meat, Poultry	7	9	18	19	0	0	1	9	10	3	7	1	20	11	31	7	0
Egg, Roes	4	4	8	7	0	0	4	8	8	1	2	13	2	16	0	0	10
Milk	20	9	12	13	5	0	46	22	2	3	13	14	4	29	2	1	0
Vegetables	15	2	4	0	3	23	10	6	14	4	21	48	5	8	6	49	0
Fruits	10	3	1	0	6	15	2	1	3	1	8	3	3	3	3	23	0
Fungi	0	0	1	0	0	1	0	1	1	0	1	0	1	2	3	0	0
Seaweeds	1	0	2	0	1	1	4	2	8	6	4	14	1	6	2	3	0
Beverage	2	1	0	0	2	0	0	0	0	0	0	0	0	0	0	2	0
Seasonings	4	5	3	11	3	1	3	3	9	51	6	1	2	3	3	0	0

NF: Non-fibrous carbohydrate, DF: Dietary fiber, Ca: Calcium, P: Phosphorus, Fe: Iron, Na: Sodium, K: Potassium, VA: Retinol potency, VB_1: Thiamin, VB_2: Riboflavin, VC: Ascorbic acid, VD: Vitamin D.
Food groups between two broken lines in Table 1 and Table 2 are derived from animal sources.

TABLE 3. Anthropometric data of the subjects for nitrogen balance study.

Age (year)	Number of Children	Height (cm)	Weight (kg)	Sitting height (cm)	Chest circumference (cm)	Head circumference (cm)	Upper arm circumfer. (cm)	Skinfold thickness Triceps (mm)	Skinfold thickness Subscapular (mm)
Boys	94	141.5±1.5	36.1±1.0	76.3±0.7	68.6±0.7	53.4±0.2	21.5±0.3	10.9±0.4	8.6±0.4
3	1	94.6[α]	14.4	54.3	51.5	51.0	15.8	12.0	9.3
5	1	112.2	19.4	63.3	57.0	53.0	17.2	8.0	5.3
6	2	110.3±1.3[β]	21.4±0.2	63.9±1.1	58.5±0.5	51.3±1.0	18.5±1.0	15.0±2.0	13.0±0.0
7	4	115.3±2.5	21.7±2.8	64.2±1.1	58.5±3.3	50.6±1.0	18.1±1.3	9.7±0.6	6.2±1.4
8	4	125.9±2.2	26.5±1.9	69.3±0.8	62.0±2.5	52.7±1.0	19.8±1.3	15.3±3.0	13.4±3.3
9	4	127.1±3.3	28.7±3.5	69.9±2.0	62.3±1.4	51.7±0.6	18.9±0.3	8.8±1.2	6.8±1.5
10	14	136.7±1.2	31.6±0.7	74.4±0.1	65.5±0.8	52.9±0.2	20.3±0.4	10.4±0.6	7.5±0.6
11	22	139.1±1.0	33.0±0.8	74.9±0.5	67.0±0.6	52.9±0.3	20.9±0.3	9.9±0.6	7.2±0.5
12	24	149.0±1.4	39.5±1.1	79.0±0.7	71.2±0.9	53.9±0.3	22.3±0.4	11.4±0.8	9.2±0.9
13	9	155.2±2.9	44.6±3.6	82.3±1.8	72.9±1.9	55.1±0.7	23.3±1.0	10.8±1.1	9.0±1.1
14	6	158.7±1.5	52.3±2.6	85.9±1.3	80.2±1.8	56.2±0.7	25.2±0.8	10.9±1.2	9.8±1.2
15	1	157.0	50.8	85.2	81.4	54.3	27.0	13.5	9.5
16	1	164.6	48.6	87.1	77.8	53.4	24.6	8.5	9.2
17	1	175.5	70.6	96.1	90.8	59.2	30.6	18.5	20.0
Girls	48	138.4±2.3	36.5±1.6	75.4±1.2	67.7±1.2	52.7±0.3	21.7±0.4	16.8±0.8	14.5±1.0
3	1	92.5	13.8	52.8	51.3	47.5	17.4	15.5	15.5
5	2	103.7±1.4	17.9±1.5	56.9±0.6	54.5±1.5	49.1±0.6	18.2±1.2	13.9±6.2	13.6±3.4
7	2	112.0±2.3	20.0±0.4	62.9±1.3	54.4±0.9	51.1±1.5	18.1±0.2	10.5±4.5	9.9±4.7
8	2	119.4±6.2	24.4±5.1	66.5±1.9	58.3±4.3	50.0±3.0	18.8±1.4	17.0±1.5	14.5±1.5
9	5	127.8±2.9	28.1±1.6	70.4±1.3	61.7±1.3	52.5±0.4	20.1±0.7	17.8±2.2	13.0±2.0
10	10	137.5±2.1	34.3±2.0	75.1±1.3	66.6±1.4	52.4±0.6	21.4±0.6	16.4±1.7	11.7±2.0
11	5	141.7±1.1	35.8±1.9	76.3±0.8	67.9±1.7	52.2±0.6	21.5±0.1	14.4±1.7	11.6±1.7
12	11	148.3±2.0	40.5±1.8	79.6±1.0	71.3±1.4	53.1±0.5	22.2±0.6	15.2±1.2	13.9±1.7
13	2	147.8±0.4	44.2±1.0	80.2±2.1	73.5±1.0	54.6±0.4	23.4±1.0	15.8±1.8	13.9±0.1
14	5	154.4±1.4	48.9±3.0	83.6±1.4	76.5±2.4	54.2±1.1	24.2±0.9	19.6±2.7	18.3±2.2
15	2	154.5±0.7	58.2±4.2	85.4±2.2	80.2±0.2	57.0±1.0	25.8±1.7	26.6±1.6	29.8±2.3
16	1	151.4	57.1	84.3	79.0	56.2	28.0	22.0	33.0
Total	142	140.4±1.3	36.2±0.9	76.0±0.6	68.4±0.6	53.2±0.2	21.6±0.2	12.9±0.4	10.6±0.5

Cicumfer.: Circumference, α: M, β: SE.

TABLE 4. Summary of results of nitrogen balance studies.

Age	Number of children	N intake[1] (mg/kg/day)	N excretion Fecal (mg/kg/day)	N excretion Urinary (mg/kg/day)	N retention (mg/kg/day)	N retention (% of intake)	Energy intake[2] (kcal/kg/day)	N intake[2] (mg/kg/day)
Boys	94	404± 8	60± 2	276± 7	69± 6	16.1± 1.2	74± 2	379± 7
3	1	433[α]	54	312	68	15.6	68	389
5	1	516	68	200	248	48.1	113	506
6	2	540±16[β]	52± 6	336± 2	152±24	28.1± 3.6	73± 1	463± 3
7	4	535±44	76±11	278±47	131±29	34.5± 6.5	100± 8	471±28
8	4	460±34	52± 7	330±24	78± 5	17.0± 0.9	67± 5	402±29
9	4	477±66	64± 8	318±37	95±29	18.5± 3.8	112±31	422±47
10	14	417±17	63± 6	300± 9	55±13	12.5± 2.6	76± 3	407±17
11	22	398±14	68± 4	279±10	51± 9	12.3± 2.1	75± 2	387±13
12	24	383±13	52± 3	247±10	58± 8	14.6± 1.9	68± 2	366±12
13	9	368±21	61± 7	259±15	48±20	11.7± 5.0	68± 4	340±25
14	6	341± 9	51± 7	211±19	79±18	23.3± 5.8	62± 4	299± 9
15	1	329	55	190	84	25.6	45	289
16	1	357	40	288	88	24.8	51	314
17	1	245	38	159	49	19.8	37	210
Girls	48	346± 9	46± 2	242± 9	58± 8	16.5± 2.2	60± 2	330± 9
3	1	381	45	319	17	4.4	59	362
5	2	334±21	47± 1	271±33	17±53	4.0±15.5	51± 2	313±18
7	2	418±20	64± 5	349±11	6±27	1.0± 6.4	76±13	395±14
8	2	437±83	57± 3	329±39	52±47	10.2± 8.7	63±11	404±75
9	5	368±21	51± 6	294±18	23±12	6.1± 3.3	63± 3	336±15
10	10	372±19	54± 5	256±12	62±16	15.9± 3.5	65± 3	365±18
11	5	346±31	43± 8	200±21	103±43	27.1±11.7	68± 7	353±30
12	11	333±18	44± 4	216±18	72±14	22.0± 4.4	59± 3	322±16
13	2	310± 3	31± 1	187± 1	92± 3	29.6± 0.7	53± 7	270±18
14	5	296±17	34± 4	206±22	56±12	19.3± 4.4	47± 4	274±16
15	2	267± 8	51±22	197± 5	19±35	6.8±12.8	46± 6	235±18
16	1	247	25	175	46	18.8	48	226
Total	142	384± 7	55± 2	265± 5	65± 5	16.2± 1.1	69± 2	363± 6

α: M, β: SE, [1]: Analytical value. [2]: Value claculated by referring to food composition tables.

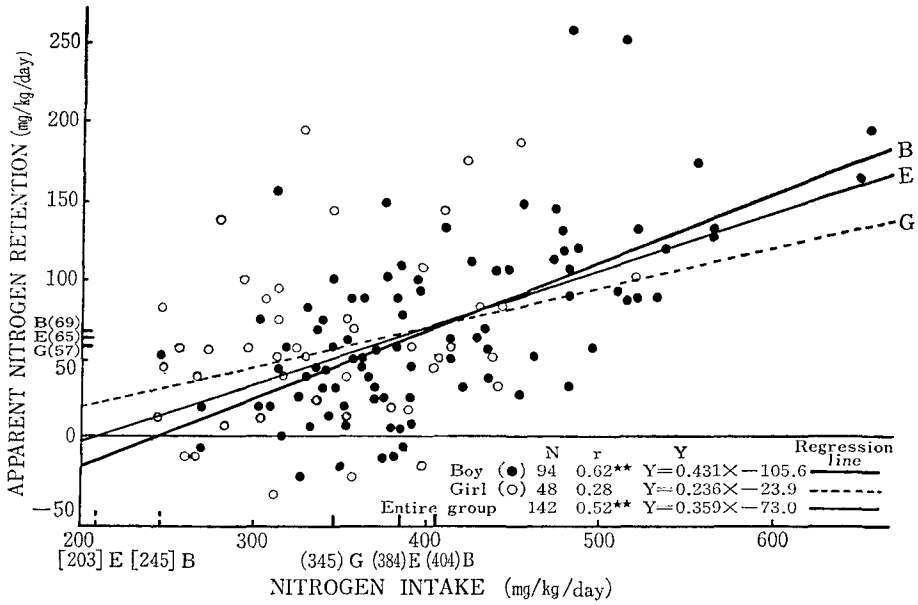


Fig. 3. Daily N retention in relation to daily N intake in 142 children 3 to 17 years old. Each dot represents in result of balance study of each child. Five observations are hidden.

[ ]: N maintenance requirement. ( ): Mean of the group.
B: Boy. G : Girl. E: Entire group.

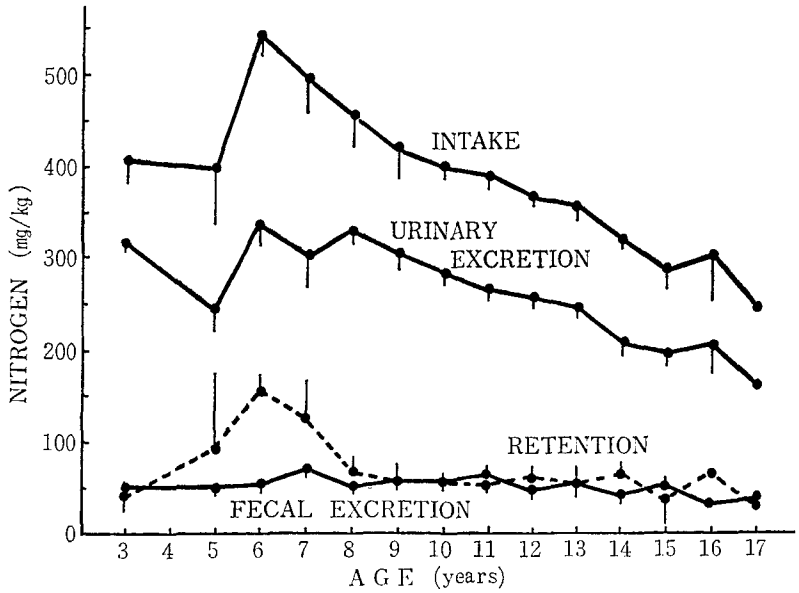


Fig. 4. Summary of N balance studies in 142 children from age 3 to 17 years. Circles and bars represent M±SE.

entire group, it was assumed that apparent NPU was 35.9%, N loss in urine and feces was 73.0 mg/kg, and N maintenance requirement was 203 mg/kg.

Fig. 4 is a summary of N balance studies by age. In the subjects 3-17 years old, concerning the unit of mg/kg/day, intake and urinary excretion tended to decrease as they grew older, though fecal excretion and retention were more or less regular. N retention indicated positive for all ages. More intensive studies should be made for age groups less than 7 years and those 15 years old, in order to clarify the relationship between N intake and N output.

Discussion

Table 5 shows the data of N balance on routine diet for normal and healthy infants and children in the countries of Japan and the USA. In this Table, the data 1, 2) by SANTO, 3) by KITANO and 4) by YAMAMOTO were obtained in Japan during a decade of 1974-1984 (10, 11), and the data 5, 6, 7, 8) by ZIEGLER were the survey results in Iowa State, USA for 23 years from 1930 to 1953 (12). Urinary and fecal excretions of endogenous N and integumental N losses (skin, nail, hair of scalp) were not determined in studies 1)-8) of Table 5. Therefore, the N balance results are of apparent values. The range of mean N intake was 384-581 mg which was of extremely higher level than those of 80 mg of egg formulae and 88 mg of milk formulae for 9-17 months of Chinese infants by HUANG (13). Therefore, the data in Table 5 revealed the fact that the N intake of routine diet was about 4-7 times of the diet based on single protein source; fecal N excretion was the range of 30-61 mg and the digestibility was 85-93% which were comparable to the data of 27 mg with 94% for egg formulae and 34 mg with 88% for milk formulae respectively by HUANG; the urinary excretion of 265-374 mg showed 4-6 times of the value by HUANG's data of 71 mg for egg formulae and 65 mg for milk diet respectively. In regard to N retention except for 5) of 149 mg which was extremely higher than the others, the range 65-95 mg was obtained, whereas, −18 mg for egg and −10 mg for milk formulae respectively by HUANG were revealed. The N retention % of the intake was the range of 13.7-23,7%, although 23.7% for 5) was nearly the same as 25% by HUANG. The energy intake of these subjects ranged 69-100 kcal and HUANG prepared 80 kcal for the experimental diets of egg and of milk formulae. The values of 2) by SANTO were approximately the same as those for 3) by KITANO except for the fecal N excretion and the digestibility.

Table 6 is the results of regression analysis for 1)-8) in Table 5, and

TABLE 5. Comparison of data on nitrogen balance and energy intake of routine diet for children by several authors in Japan and the USA.

No.	Authors	Age	Number of children	N intake	N excretion		D	N retention		Energy intake
					Fecal	Urinary			% of intake	
				(mg/kg/day)	(mg/kg/day)		(%)	(mg/kg/day)		(kcal/kg/day)
1)	SANTO	3-17 years	142 (94M, 48F)[α]	384± 7[β]	55±2	265± 5	86	65± 5	16.2±1.1	69±2
2)	SANTO	3-17 years	94 (94M)	404± 8	61±2	276± 7	85	69± 6	16.1±1.2	74±2
3)	KITANO *et al.*[10]	3- 6 years	31 (16M, 15F)	403± 9	30±1	303± 6	93	70± 8	17.4±1.6	75±2
4)	YAMAMOTO *et al.*[11]	1- 2 years	22 (10M, 12F)	460±13	33±2	338±12	93	90±10	19.5	78±2
5)	ZIEGLER *et al.*[12]	12-18 months	21 (12M, 9F)	581±11				149±10	23.7±1.1	100±2
6)	ZIEGLER *et al.*[12]	18-36 months	20 (14M, 6F)	546± 5				95± 3	17.0±0.1	91±1
7)	ZIEGLER *et al.*[12]	3- 6 years	32 (30M, 2F)	507± 6	51±1	374± 5	90	82± 2	15.8±0.4	90±1
8)	ZIEGLER *et al.*[12]	6-11 years	63 (54M, 9F)	447± 4	44±1	339± 3	90	64± 2	13.7±0.4	81±1

[α]: M, male; F, female. [β]: M±SE. The SE and digestibility (D) were recalculated from the authors' references by SANTO.

TABLE 6. Regressions of nitrogen retention on nitrogen intake derived from routine and experimental diets of various countries.

No.	Authors	No. of subject	Age	Regression equation $Y=AX-E$	r	Signi-ficance	N maintenance requirement (B)	Energy intake @	Ratio (B)/(E)	Diet
1)	SANTO	142	3-17 yr	$Y=0.359X-73.0$	0.522	$p<0.01$	203		2.9	
2)	SANTO	94M	3-17 yr	$Y=0.431X-105.6$	0.621	$p<0.01$	245		2.3	
3)	KITANO *et al.*[10]	45	3- 6 yr	$Y=0.395X-84.9$	0.624	$p<0.01$	215		2.5	
4)	YAMAMOTO *et al.*[11]	22	1- 2 yr	$Y=0.327X-60.7$	0.427	$p<0.01$	186		3.0	
5)	ZIEGLER *et al.*[12]	21	12-18 mo	$Y=0.635X-219.6$	0.839	$p<0.01$	346		1.6	
6)	ZIEGLER *et al.*[12]	20	18-36 mo	$Y=0.330X-84.4$	0.554	$p<0.01$	256		3.0	
7)	ZIEGLER *et al.*[12]	32	3- 6 yr	$Y=0.228X-33.8$	0.524	$p<0.01$	148		4.4	
8)	ZIEGLER *et al.*[12]	63	6-11 yr	$Y=0.341X-88.1$	0.581	$p<0.01$	258		2.9	
Additional data of nitrogen balance on experimental diet in Japan and China.										
9)	HUANG *et al.*[13]	10	9-17 mo	$Y=0.706X-75.11$	0.97	$p<0.01$	106	80	1.4	(Egg)
10)	HUANG *et al.*[13]	24	9-17 mo	$Y=0.690X-70.97$	0.94	$p<0.01$	103	80	1.5	(Milk)
11)	KOMATSU *et al.*[14]	5M	Adult	$Y=0.390X-44.5$	0.84	$p<0.01$	115	45	2.6	(Customary)
12)	INOUE *et al.*[16]	11M	Adult	$Y=0.411X-37.03$	0.78	$p<0.01$	90	45	2.4	(Egg)

In 1)-8), Y: apparent N retention, A: apparent NPU, X: N intake, E: apparent obligatory fecal and urinary N losses, In 9)-12), Y: N retention, A: NPU, E: obligatory N excretion, Unit of N: mg/kg/day, M: male, @: kcal/kg/day, yr: years old, mo: months old.

additional data determined obligatory endogenous N and integumental N losses for 9)-12). Apparent net protein utilization (NPU) expressed as percentage of the slope of regression line, except for 5), ranged from 23 to 43%. For 5), the apparent NPU as 64% was somewhat closer to 71% for egg formulae and 69% for milk formulae by HUANG than the others in Table 6, so it is assumed that the diet protein for 5) by ZIEGLER was influenced by egg and milk. Regarding to the NPU for adult male, KOMATSU *et al.* (14) reported as 39% on a customary diet in Japan, whereas the values for 1) and 2) by SANTO and 3) by KITANO in Table 6 were close to 39%. The apparent NPU values of 4) by YAMAMOTO and 6) by ZIEGLER showed 33% the same as each other. In regression equation, it is assumed that the second term on the right side is obligatory N excretion. According to SANTO's present results, the apparent obligatory N excretion was 73 mg for 142 children and 105.6 mg for 94 boys. In Table 6, the apparent obligatory N excretion ranged 33.8-219.6 mg as a whole of 1)-8), and 60.7-105.6 mg for the group except 5) and 7) on routine diets for children. These data included 75.11 mg and 70.97 mg of obligatory N excretion for egg formulae and milk formulae respectively by HUANG. Table 12 of FAO/WHO report in 1973 (15) shows obligatory N loss computed as 73 mg for 9-year-old children, and 72 mg and 68 mg for 10-year-old boys and girls respectively. SANTO's subjects of 1) in Table 6 were 10.6 years of age as average, so it is considered that this subjects' apparent obligatory N excretion was very close to the data of 1973 FAO/WHO. Concerning the subjects of Japanese adult men on customary diet, KOMATSU (14) reported 44.5 mg of obligatory N excretion. SANTO's subjects showed 1.6 times of the value for the adult men.

On the other hand, the regression line of 1) in Table 6 by SANTO cut the abscissa at N intake of 203 mg, which was the estimate as the apparent N maintenance requirement, and comparable to 175% of the N maintenance requirement for adults fed a customary diet reported by KOMATSU. The apparent N maintenance requirements which are shown in the next column from the right side of 1)-8) in Table 6, except for 5) and 7), ranged 186-258 mg, especially the value for 6) showed almost the same one as 8). The N maintenance requirements were 106 mg and 103 mg on egg and on milk diets respectively for infants by HUANG; 90 mg on egg diet for adult men by INOUE *et al.* (16); 87 mg on fish diet, 118 mg on soybean diet, 91 mg on mixed protein diet of fish and soybean for adult men by WANG *et al.* (17); 115 mg on a customary diet by KOMATSU for adult men. As the apparent N maintenance requirement, 245 mg for 2) and 215 mg for 3) in Table 6 showed almost twice of the value of adult men fed a customary diet and

soybean diet.

The ratio of N maintenance requirement to obligatory N excretion, arranged for the right side column in Table 6, ranged 2.3-3.0 for 6 experiments, except for 5) and 7) among the childrens' group on routine diets, whereas 1.6 for 5) was close to the values for 9) and 10) derived from egg or milk diet for infants, and the rest among 1)-8) except for 5) and 7) were similar to those of 11) and 12) for adult men.

In Table 7, both data by SANTO and by ZIEGLER show that N absorption versus N intake, and urinary N excretion versus N intake are highly correlated, regardless of age and sex, and the same tendencies reveal in Fig. 4 that both of urinary N excretion and N intake decrease with advancing age, whereas fecal N excretion and N retention show little change. However, N retention versus N intake and % N retention versus N intake of female subjects by SANTO were not significantly correlated. The reason has remained in unexplained.

In this study, the previous diet history of the subjects could be disregarded, because the subjects' stay term in the same orphanage was 3 years and 6 months as an average. In each orphanage, the menu was usually

TABLE 7. Relations among parameters of nitrogen balance and energy intake

Parameters[α]		Male[γ] 3-17 yr	Female[γ] 3-17 yr	Entire[γ] group	Male and female[δ] 3-6 yr	6-11 yr
Author		SANTO	SANTO	SANTO	ZIEGLER	ZIEGLER
Number of studies		94	48	142	302	496
Correlation coefficient[β]						
N intake	vs energy intrke	0.565@	0.710@	0.638@	0.266	0.672
N absorption	vs N intake	0.970	0.973	0.972	0.990	0.985
Urinary N excretion	vs N intake	0.714	0.685	0.724	0.882	0.780
N retention	vs N intake	0.621	0.283(NS)	0.522	0.524	0.581
% N retention	vs N intake	0.382	0.066(NS)	0.245*	0.231	0.374
N retention	vs N absorption	0.685	0.402	0.603	0.525	0.606

α: Expressed mg per kilogram of body weight except where indicated as percentage of intake.

β: All values are highly significant ($p<0.001$) except for *($P<0.01$) and (NS) non significance.

γ: Data by SANTO based on analytical value except @ based on calculated value.

δ: Data by ZIEGLER *et al.*

yr: Years old.

% N retention: N retention % of N intake.

planned as one-month-unit by a dietitian with all staffs' advices including the dishes requested by the children under these circumstances of fulfilment of nutritional, emotional, economical and social needs factors amounting to 800-900 yen per child per day for food expenditure in 1983-1984. Their budget is provided by the governments. There is also an inspection and guidance on health improvement program including menu planning by an administrative dietitian from Hokkaido Prefectural Government yearly.

My intention was to establish relationships between N intake and N retention in normal and healthy children of various ages receiving customary diets commnly consumed in Japan. It was actually impossible to obtain data involving facts pertaining to children living with their families. Thus, the author studied these groups controlled in the orphanages.

The PFC energy ratios for 464 subjects equals 13 : 31 : 56 denoting that it attains the goal of the Japanese diet as well as that for the USA (18). Nutrients, except for vitamin D, were quite adequate according to the JRDA. This desirable situation depended on 1) the budgets from the government; 2) especially, the supervisors' endeavors to understand the nutritional circumstances and to lead their employees (instructors, nurses, cooks and janitors); 3) the untiring efforts of supervisors and their staffs who gave warm loving care to eccentric youngsters from broken homes, which eventually led to their emotional stability; 4) and the assignment of a dietitian in each social welfare institution by national regulations since 1979 was a good step forward in the advancement of child welfare.

This desirable situation, however, does not seem to exist among the children in general in Japan; — for the popular use of fast-foods, take-out foods, etc. has been evident, judging from the flourishing enterprises that are widespread at present. Quite a number of children have skipped their meals or have had ones with poor content. Besides, they seldom enjoy meals together with family members (19). As they grow older, it is alarming that one young man out of three in their twenties have no breakfast according to the national nutrition survey (20).

Nevertheless, the adequacies of minerals and vitamins for orphanage children are not always quite as satisfactory. Table 1 reveals excess intake of VB_1, 2.6, and of Na, 1.6, as nutrient adequacies. According to Table 2, 51% of Na was derived from seasonings which needs to be reduced, and 53% of VB_1 was provided mainly by grains (enriched rice). Before entering orphanages, children were often accustomed to poor dietary habits consuming ready-to-eat food seasoned with excess salt or sugar. Rice, our staple food, is available at a fixed standard of an addition of 0.5% enriched rice to

polished rice enforced since about 1955, the period when Japan was not as well nourished as today. In spite of abundance of food at present, it seems puzzling that rice is enriched at the same rate of thirty years ago.

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References

1) Ministry of Health and Welfare: Recommended Dietary Allowances for Japanese 3rd ed. (in Japanese), p. 184. Daiichi Shuppan, Tokyo, 1984
2) Ministry of Health and Welfare: Recommended Dietary Allowances for Japanese 2nd ed. (in Japanese), p. 187. Daiichi Shuppan, Tokyo, 1979
3) INOUE, G., YOSHIOKA, T., KOISHI, H., NIIYAMA, Y. and TAESHIMA, Y.: A note on daily protein intake and nitrogen retention of the school children in Japan (in Japanese), *J. Faculty of Science of Living, Osaka City Univ.*, **9**: 29-35. 1961
4) MATSUDAIRA, T., OKUDA, T. and KOISHI, H.: Nitrogen balance of children living in a child welfare institution (in Japanese), *Nippon Eiyo Shokuryo Gakkaishi*, **38**: 443-451. 1983
5) SANTO, S.: Dietary effects on physique of growing children in Hokkaido orphan-

ages, (in Japanese), *Memoirs Faculty of Agric. Hokkaido Univ.*, **13**: 342–422. 1982

6) Resources Council, Science and Technology Agency, Japan: Standard Tables of Food Composition in Japan 4th ed., p. 707, Ministry of Finance Printing Office (in Japanese), Tokyo, 1982
7) KAGAWA, Y.: Shihan Shokuhin Seibunhyo (in Japanese), p. 365. Joshi Eiyo Daigaku Shuppan-Bu, Tokyo, 1983
8) PAUL, A. A. and SOUTHGATE, D. A. T.: McCance and Widdowson's the Composition of Foods, 4th ed. of MRC Special Report No. 297, p. 418. Her Majesty's Statistical Office, London, 1978
9) Resources Council, Science and Technology Agency, Japan: Standad Tables of Food Composition in Japan 3rd ed. (in Japanese), p. 118. Ministry of Finance Printing Office, Tokyo, 1963
10) KITANO, T., TAKAHASHI, M., IKEHATA, K., OGURA, K., KAJIWARA, N., MATSUDAIRA, T. and KOISHI, H.: Nitrogen balance and energy availability in preschool children (in Japanese), *Nippon Eiyo Shokuryo Gakkaishi*, **37**: 203–208. 1984
11) YAMAMOTO, S., UEZU, N., IKEMOTO, S., WANG, M. F., KISHI, K., OKADA, Y., TANIMOTO, H. and INOUE, G.: Protein and energy intakes and nitrogen balance in 1- and 2-year-old children (in Japanese), *Nippon Eiyo Shokyryo Gakkaishi*, **37**: 171–176. 1984
12) ZIEGLER, E. E., O'DONNELL, A. M., STEARNS, G., NELSON, S. E., BURMEISTER, L. F. and FOMON, S. J.: Nitrogen balance studies with normal children, *Am. J. Clin. Nutr.*, **30**: 939–946. 1977
13) HUANG, P. C., LIN, C. P. and HSU, J. Y.: Protein requirements of normal infants at the age of about 1 year, maintenance nitrogen requirements and obligatory nitrogen losses, *J. Nutr.*, **110**: 1727–1735. 1980
14) KOMATSU, T., KISHI, K., MATSUMOTO, Y. and INOUE, G.: Requirements and NPU of mixed protein in routine diets for adult Japanese men (in Japanese), *Proc. 33rd Annual Meeting Japanese Soc. Nutrition and Food Science*: 99. 1979
15) Joint FAO/WHO Expert Committee in Energy and Protein Requirements: Energy and Protein Requirements. Wld Hlth Org. tech. Rep. Ser., No. 522, World Health Organization, Geneva, p. 47. 1973
16) INOUE, G., FUJITA, Y. and NIIYAMA, Y.: Studies on protein requirements of young men fed egg protein and rice protein with excess and maintenance energy intakes, *J. Nutr.* **103**: 1673–1687. 1973
17) WANG, M. F., KISHI, K., TAKAHASHI, T., KOMATSU, T., OHNAKA, M. and INOUE, G.: Efficiency of utilization of soy protein isolate in Japanese young men, *J. Nutr. Sci. Vitaminol.*, **29**: 201–216. 1983
18) Select Committee on Nutrition and Human Needs, US Senate: Dietary Goals for The United States, U. S. Government Printing Office, Washington, pp. 79. 1977
19) ADACHI, M. and The Group of "Morning Plaza" by NHK.: "Why do you eat alone" (in Japanese), Sanyo-sha, Tokyo, p. 214. 1983
20) Ministry of Health and Welfare: Aspects of National Nutrition —Results of National Nutrition Survey in 1983— (in Japanese), Daiichi Shuppan, Tokyo, p. 88. 1985