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Original Article

A Validation Study on Food Composition Tables for the International Cooperative INTERMAP Study in Japan

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Abstract

Objective: The INTERMAP Study is an international cooperative study on the relationship between macro- and micro-nutrient intakes and blood pressure. The present study—ancillary to INTERMAP—is to evaluate validity of the INTERMAP Tables of Food Composition in Japan (ITJ) formulated by modifying the Standard Tables of Food Composition in Japan (STJ), including factoring in changes in weight and nutrient composition of individual foods due to cooking.

Methods: With chemical analytical values of 96 meals prepared in two university hospitals in Japan as the "gold standard", validity of calculated values based on the ITJ was examined for six major components (energy, protein, lipid, carbohydrate, sodium, potassium) by comparison of mean values, correlation, and linear regression analysis.

Results: Although both the ITJ-based and STJ-based calculated values for all six components were significantly higher than the analytical values, differences from the analytical values were generally less marked for the ITJ-based values than for the STJ-based values. The STJ-based values were significantly higher than the ITJ-based values for protein and potassium. Analytical values showed slightly stronger correlations with the ITJ-based calculated values (r=0.876 for total energy, r=0.789 for lipid, r=0.832 for potassium) than with the STJ-based calculated values, except for carbohydrates.

Conclusions: The ITJ was considered to have greater validity than the STJ. To obtain more accaurate data in nutritional surveys, food composition tables in which changes in nutrient compositions due to cooking methods are taken into consideration should be used.

Key words: food composition tables, dietary assessment, nutrient intake, validation study, Japan

Introduction

The international cooperative study INTERMAP (the INTERMAP Study) was conducted in four countries (Japan, People's Republic of China, United Kingdom, United States), with the aim of clarifying relationships between nutrient/food intakes of individuals and their blood pressures. This research involved nutrition surveys using highly standardized methods for 24-hour dietary recalls, and accurate sphygmomanometry, on four separate occasions (1–4). Participants of the INTERMAP Study were men and women aged 40 to 59. Altogether, 4,680 persons were surveyed from 17 population samples across the four countries. In Japan, 1,145 persons were

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surveyed, in Sapporo, Toyama, Shiga, and Wakayama, between 1996 and 1998.

In the INTERMAP Study it was necessary to obtain the most accurate data possible on type and quantity of nutrients taken by each participant, so that individual intake could be characterized as precisely as possible, with nutrient data as comparable as possible across the four countries. However, the Standard Tables of Food Composition in Japan (5), which had been widely used in Japan, mainly express nutrient values of foodstuff components in the raw uncooked state. Changes in weight and nutrient content due to cooking and/or processing are not considered in the information provided by the STJ, and—in the estimation of meal nutrient content—only raw ingredients have been used without adjustments for cooking losses. On the other hand, tables of food composition used in the U.S. and the United Kingdom feature values measured after cooking. Therefore, we developed a new database for raw and cooked Japanese foods, called INTERMAP Tables of Food Composition in Japan (ITJ) (6, 7), based on the Standard Tables of Food Composition in Japan, Fourth Revised Edition (STJ) (5), taking into consideration methods of food preparation and various research reports and data (8–17). In addition, the ITJ contains data on additional foodstuffs and nutrients not covered by the STJ, including processed foods, special seasonings, and supplements (7).

In the present study, major components (i.e., energy, protein, lipid, carbohydrate, sodium, and potassium) of sample meals prepared in hospitals were measured and analyzed chemically, and the obtained analytical values of those foods were regarded as the gold standard. Comparisons were then made between the analytical values and the two kinds of calculated values based on the ITJ and the STJ for these components in order to examine the validity of the ITJ.

Materials and Methods

Preparation of the INTERMAP Tables of Food Composition in Japan

The ITJ is based on the STJ; its details are published (6, 7). In order to reflect changes in nutrients caused by different food preparation methods, the ITJ defines the various methods, classifies them into 10 types, and assigns each type a preparation code. This is a distinctive feature of the ITJ. Specifically, preparation methods are divided into "boiling", "grilling on mesh", "stewing", "pan-frying", "eating raw", and "others". The first four methods of cooking are subdivided into "thick" and "thin", according to the thickness of the material. Weight change rates of foodstuffs and residual levels of nutrients resulting from different cooking methods were estimated and added in as data on nutrient composition after cooking. The following example illustrates how raw to cooked conversion factors for beef meat data estimated from Japanese reference were used to estimate nutrient content for grilled beef meat in the ITJ: raw chuck beef contains 16.4 g fat/100 g (STJ); nutrient retention of fat in grilled beef is estimated as 83% (13); yield of grilled beef is estimated as 87% (13); 16.4 g fat × 83% retention=13.6 g fat per 87 g cooked yield=15.6 g fat per 100 g grilled beef. US conversion factors (18, 19) were used for foods and nutrients for which there were no Japanese references.

Finally, foodstuffs in the STJ were reviewed; data on reported processed foods were added; macro- and micronutrients, etc. (trace elements, fatty acid composition, amino acid composition, and dietary fiber) of foodstuffs not covered in the STJ were estimated using other data sources (20–24), and their data included. Data on nutrients of each foodstuff not covered by the STJ were calculated from similar foods in reference sources by adjustment for representative nutrients. Detailed methods are described elsewhere (7, 9, 25).

Samples and recipes

For this research, precise recipes were prepared, and dishes were cooked exactly as the recipes prescribed. Sample sources were 96 meals cooked on four consecutive days of August–September 2000 in two university hospitals in the Kanto and the Chubu regions.

The 96 meals comprised four groups of 24 meals, representing four types of diet: usual, low energy control, sodium control, and hemodialysis. The 'usual' diet is a standard hospital diet, similar to one taken by average healthy Japanese in everyday life (26). The low energy control diet is a hospital diet primarily used for treatment of obesity or diabetes, in which the amount of energy is controlled at 60–65% of that in a usual diet. The sodium control diet, in which the amount of sodium (salt) is reduced, is for treatment of high blood pressure, cardiac diseases, etc. The hemodialysis diet, in which the amounts of water, sodium, potassium, and phosphorus are especially limited, is for patients undergoing dialysis due to chronic renal failure. These four types of diet were chosen as samples to obtain a scatter of data reflecting nutrition quantities influenced by both varieties of cooking methods and of nutrients supplied in different types of diet.

To minimize the chance of error resulting from different serving sizes, five servings of the same meal were always used for sampling, and data on nutrient quantity in the five dishes were collected. The five servings were homogenized, and part of the homogenate was analyzed.

Methods of analysis

Amount of energy and nutrients (analytical values) contained in each of the hospital meals were measured by analytical specialists in Japan who employed the following methods to determine nutrient concentration values: Protein was measured by the Kjeldahl method (nitrogen to protein conversion coefficient: 6.25), and lipids by the acid decomposition method (27). The weight of carbohydrates was obtained by subtracting the total weight (grams) of water, protein, lipids, and ashes from the gross weight (grams) of each relevant meal. Water was measured by air oven method, and ashes were measured using ignition at 550 degrees centigrade. Energy was calculated by energy conversion coefficients (protein: 4 kcal/g, lipids: 9 kcal/g, and carbohydrates: 4 kcal/g). Values of sodium and potassium were obtained by atomic absorption analysis after dry ashing (SpectrAA, Varian, Inc., Australia).

Computation of nutrient content based on recipe

Energy and nutrient content were computed based on both the ITJ and STJ, using the recipe for each of the hospital meals. Experienced Japanese registered dieticians controlled the two methods used to compute the nutrient content of the meals shown in the recipes. However, using the ITJ for this calculation required an accurate understanding of its preparation code system and prescribed methodology; therefore, computations according to the ITJ could only be carried out by registered dieticians who, in accordance with the protocol of the INTERMAP Study, had participated in an official training session, passed a designated examination, and been certified as nutrition survey staff by the Central Secretariat of the INTERMAP Study (3, 6).

Evaluation

Energy and five nutrients (protein, lipids, carbohydrates, sodium, and potassium) were examined in this study. Averages were determined for analytical values and the calculated results for energy and the five nutrients in all 96 meals (based on the ITJ and the STJ), and the obtained mean values were compared with the analytical results by Scheffe's method. Relationship between these values was also examined using Pearson's correlation coefficients. Simple linear regression analyses were performed to observe regression lines. The analyses were performed using the SPSS for Windows 11.0J (SPSS Inc.).

Results

The mean analytical values and the two kinds of calculated values (ITJ and STJ) for energy and the five nutrients contained in all 96 meals are shown in Table 1. The ITJ- and STJ-based calculated values for energy and all five nutrients were significantly higher than the analytical values, with the values of these components calculated from the ITJ nearer to the analytical values than those derived from the STJ, except for carbohydrate. In addition, the STJ-based calculated values of protein and potassium were significantly higher than the ITJ-based calculated values.

Table 2 shows the mean analytical values and the ITJ- and STJ-based calculated values for energy and five nutrients contained in 24 meals in each of the 4 types of hospital diet. For a usual diet, the STJ-based calculated values for protein and lipid were significantly higher than the analytical values, and both of the calculated values for energy, sodium and potassium

Table 1 Comparison of means of analytical values and two kinds of calculated values for all 96 meals

	Food Analysis	ITJ	STJ
Energy (kcal)	482.7±116.7	531.0±114.9***	542.9±121.9***
Protein (g)	21.6±5.0	22.4±4.6*,††	23.4±5.4***
Lipid (g)	12.2±5.0	14.4±6.4***	15.1±7.0***
Carbohydrate (g)	71.5±22.6	75.4±19.2***	75.4±18.8***
Sodium (mg)	833.0±382.8	1052.0±460.8***	1080.3±473.8***
Potassium (mg)	547.9±201.0	786.4±227.1***,†††	851.4±241.8***

Values are means±SD.
* p<0.05, *** p<0.001, versus food analysis by Scheffe's method.
†† p<0.01, ††† p<0.001, versus STJ by Scheffe's method.
ITJ, calculated values using the INTERMAP Tables of Food Composition in Japan; STJ, calculated values using the Standard Tables of Food Composition in Japan.

Table 2 Comparison of means of analytical values and two kinds of calculated values in meals from four types of hospital diet

	Food Analysis	ITJ	STJ
Usual diet (n=24)			
Energy (kcal)	615.0±56.8	647.5±65.6*	664.7±72.3***
Protein (g)	25.4±5.0	26.1±3.8	27.4±4.4**
Lipid (g)	14.8±4.8	16.5±6.9	17.7±7.7*
Carbohydrate (g)	94.9±13.2	94.9±11.3	94.8±10.4
Sodium (mg)	1324.3±313.5	1627.7±336.5***	1663.7±379.9***
Potassium (mg)	622.3±155.7	891.1±162.7***,†	960.7±168.7***
Low energy control diet (n=24)			
Energy (kcal)	387.3±44.3	410.3±51.3***	416.1±51.0***
Protein (g)	20.4±3.9	21.1±3.3	21.7±3.6*
Lipid (g)	10.7±3.2	11.5±3.8	11.8±3.7
Carbohydrate (g)	52.2±8.1	53.9±8.9*	54.1±8.4*
Sodium (mg)	775.9±158.0	955.4±232.4**	986.5±222.0***
Potassium (mg)	578.1±204.6	824.6±222.0***	886.5±243.1***
Sodium control diet (n=24)			
Energy (kcal)	400.2±84.0	507.1±94.4***	511.3±92.7***
Protein (g)	21.1±3.8	22.9±4.0**	23.6±4.1***
Lipid (g)	10.7±5.0	13.4±6.4***	13.5±6.4***
Carbohydrate (g)	54.9±12.7	71.5±14.0***	71.3±13.7***
Sodium (mg)	814.3±151.8	1029.0±252.0***	1047.9±244.6***
Potassium (mg)	604.9±202.6	849.0±222.2***	912.0±253.8***
Hemodialysis diet (n=24)			
Energy (kcal)	528.2±82.5	558.9±86.7*	579.6±98.9***
Protein (g)	19.4±4.8	19.6±4.6	21.1±6.6
Lipid (g)	12.7±5.5	15.9±6.7***	17.6±7.4***
Carbohydrate (g)	84.0±17.1	81.3±13.6	81.4±12.7
Sodium (mg)	417.5±149.0	595.8±263.1***	623.2±292.2***
Potassium (mg)	386.3±136.4	580.8±150.0***,†	646.2±151.8***

Values are means±SD.
* p<0.05, ** p<0.01, *** p<0.001, versus food analysis by Scheffe's method.
† p<0.05, versus STJ by Scheffe's method.
ITJ, calculated values using the INTERMAP Tables of Food Composition in Japan; STJ, calculated values using the Standard Tables of Food Composition in Japan.

Table 3 Pearson's simple correlation coefficients between food analysis values and two kinds of calculated values for all 96 meals

	ITJ	STJ
Energy	0.876***	0.870***
Protein	0.848***	0.819***
Lipid	0.789***	0.787***
Carbohydrate	0.870***	0.883***
Sodium	0.896***	0.895***
Potassium	0.832***	0.751***

* p<0.05, **p<0.01, ***p<0.001.
ITJ, calculated values using the INTERMAP Tables of Food Composition in Japan; STJ, calculated values using the Standard Tables of Food Composition in Japan.

Table 4 Linear regression equations of food analysis values (x) in relation to two kinds of calculated values for all 96 meals

	ITJ (y_1)	STJ (y_2)
Energy	y_1=0.863x+115	y_2=0.909x+104
Protein	y_1=0.791x+5.32	y_2=0.886x+4.30
Lipid	y_1=1.005x+2.06	y_2=1.094x+1.75
Carbohydrate	y_1=0.739x+22.5	y_2=0.732x+23.0
Sodium	y_1=1.079x+153	y_2=1.108x+158
Potassium	y_1=0.940x+272	y_2=0.903x+357

ITJ, calculated values using the INTERMAP Tables of Food Composition in Japan; STJ, calculated values using the Standard Tables of Food Composition in Japan.

were significantly higher than the analytical values. The STJ-based calculated value for potassium was significantly higher than the ITJ-based value. Similar results were observed on a low energy control diet. On a sodium control diet, the calculated values for all components from both the ITJ and STJ were significantly higher than the analytical values. On a hemodialysis diet, the STJ-based calculated value for potassium was significantly higher than the ITJ-based value.

Table 3 shows correlation coefficients between the analytical values and the two kinds of calculated values for energy and the five nutrients contained in all 96 meals. They all show significantly positive correlations, but the correlation coefficients between the analytical values and the ITJ-based calculated values for energy, protein, lipids, sodium and potassium were slightly higher than STJ-based coefficients.

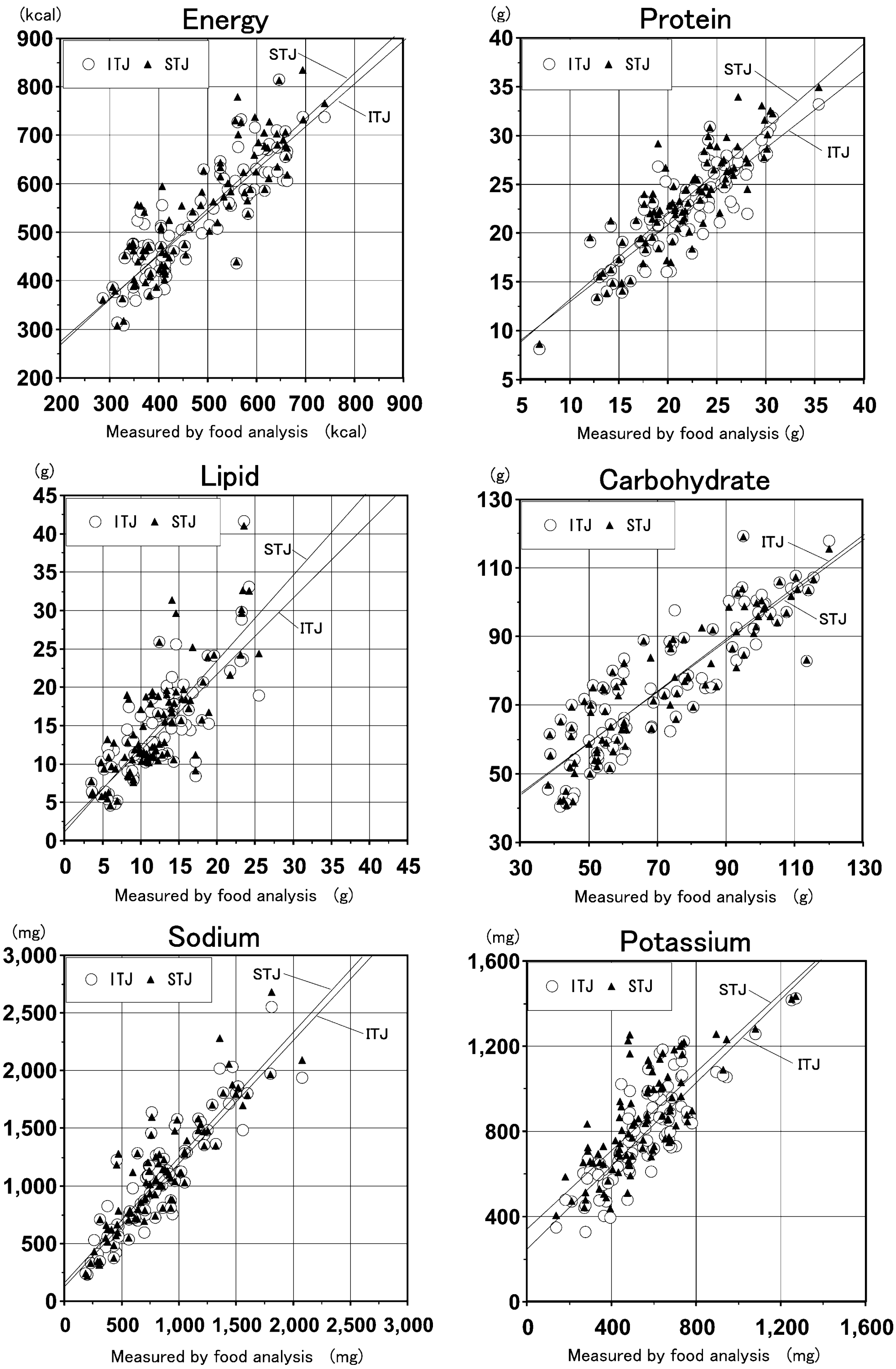

Fig. 1 Scatter diagrams and linear regression lines of analytical values and the two kinds of calculated values for energy and five nutrients (ITJ-based and STJ-based).

Figure 1 shows scatter diagrams and linear regression lines between the analytical values and the two types of calculated values for energy and the five nutrients, from the ITJ and STJ respectively. The equations of linear regression are shown in Table 4. Except for carbohydrate, regression lines for ITJ tended to be under those for STJ and to be closer to a line y=x.

Discussion

Dietary assessments used in epidemiological research include dietary records, food frequency, brief dietary assessment methods, diet history, 24-hour dietary recall, and other methods (28), each with merits and drawbacks, and no universal or "gold standard" method exists (29, 30). Therefore, the approach generally is to select a dietary assessment method most likely to suit a particular research group.

The "24-hour dietary recall" used in the INTERMAP Study has the following advantages: The burden imposed on participants is comparatively slight, because they have only to recall the content of meals taken on the day before the interview; there is little likelihood of influencing the eating habits of participants, because the interview about their meals is conducted after they have eaten; and the method can be used for participants who cannot read or write (28). For the INTERMAP Study, a detailed protocol common to all participating centers and countries was laid down to secure maximum standardization. This protocol specifies how to handle data in cases where a participant's memory or answers are vague, and sets out survey procedures, including quality control of data, to be followed by all (2, 3). Because a single 24-hour dietary recall is often limited and inadequate for characterizing usual current nutrient intakes of an individual, the INTERMAP Study conducted four 24-hour dietary recalls for each participant.

Reliability and validity of obtained data from nutrition surveys can vary depending on the accuracy of the food composition database utilized to compute intakes of energy and nutrients. The Standard Tables of Food Composition in Japan (STJ), published by the Science and Technology Agency in 1982, were used in the preparatory stage of the INTERMAP Study in Japan. The STJ featured a total 1,621 foodstuffs and showed values for energy and nutrient content per 100 g of edible portion of each foodstuff (5). However, the values for the majority of foodstuffs shown in the STJ were composition values for food in the raw, and therefore could not reflect changes in either the weight and/or nutrient content of individual foods due to cooking. Also, with changes in Japanese dietary habits and lifestyles, more and more new foodstuffs, supplements, and medicines intended mainly to replenish certain nutrients had come onto the market since compilation of the STJ data on the 1,621 foodstuffs. Therefore, it was concluded that the STJ database (the fourth edition) was inadequate for the calculation and evaluation of the energy and nutrient intakes needed for the INTERMAP Study. Consequently, the new ITJ developed based on the STJ platform would be superior to STJ, taking into consideration various research reports into consideration and adding new data (8–17) to improve validity and scope (6, 7). After the INTERMAP study, the fifth edition of the STJ database was published in Japan, in which changes in nutrient content after cooking are now considered in many foodstuffs; however, measurements of this are still insufficient for many other items (31). In the present study, we used analytical values of foods actually cooked in hospitals as the gold standard to compare with ITJ-based computations of values for energy and nutrient intakes and to assess validity of the ITJ. Hospital meals are suitable for this research purpose because their recipes are made by a registered dietitian and they are usually cooked without large variation in nutrient content. However, using hospital meals in this study can also be a limitation because hospital meals may be somewhat different from ordinary community-based meals, which the INTERMAP study investigated.

Several studies have already been done in Japan to compare analytical values with calculated values, or to examine changes in nutrient content after cooking (32–39). Sugawara et al. analyzed protein, carbohydrates, lipids, and sodium in typical everyday meals consumed by Japanese, and compared analytical with calculated values, using data obtained by weighing sample foods and referring to the Standard Tables of Food Composition in Japan, 3rd Revised Edition Supplement (40) available at that time (32, 33). Their study found no statistically significant differences between the analytical values and the calculated values for protein, carbohydrates and lipids, and they reported that the correlation coefficient for protein was 0.933, carbohydrates 0.865, and lipids 0.802. Although their methods and conditions of analysis, as well as the food composition tables, were different from those in our study, the correlation coefficients between the analytical values and the ITJ-based calculated values obtained in our study were similar. On the other hand, statistically significant differences were found between the ITJ-based and STJ-based calculated values for protein, and the analytical values for protein and lipid were closer to the ITJ-based values than to the STJ-based values. From these results, the ITJ is considered to be superior to the STJ for obtaining calculated values closer to the actual nutrient values of meals, especially where meats, fish, eggs, or other foodstuffs rich in protein or lipids are extensively used, or where oil is used in cooking, because the ITJ database takes into account both changes in weight and composition due to cooking, and oil absorption rates.

In the present study, significant differences were found between the analytical values and the two kinds of calculated values for sodium and potassium; the values calculated from both ITJ and STJ were significantly higher than the analytical values. Earlier studies found that values calculated by tables of food composition tend to be higher than analytical values; the results of our study are consistent with these findings (36–39). While some community-based studies reported that all the correlation coefficients obtained in their studies were around 0.3, or not significant (32, 35), the correlation coefficients obtained in our study were 0.75 or more, indicating positive correlations between the analytical values and the ITJ- and STJ-based calculated values. Such close correlations in our study may be due to the fact that the precise quantities of ingredients and seasonings were obtained from the recipes for these hospital-cooked sample meals, while nutrition values in community-based studies are usually calculated based on self-reported dietary records by study participants. However, substantial differences were found between the analytical values and the calculated values for both sodium and potassium. Use of hospital recipes and preparation techniques may have contributed to these differences as the level of food handling may be greater than is usual for home preparation. Thus, methods used to prepare the foods and recipes may have increased surface area exposed during cutting, rinsing, and handling and therefore decreased the electrolyte content in a given food. Potassium content in foods may also tend to decrease in the process of preparation of hospital meals, because foodstuffs are meticulously washed and heated with a view to preventing food poisoning. However, it is noteworthy that the ITJ-based value for potassium was significantly lower than the STJ-based value and closer to the analytical value, probably because changes in nutrient composition due to cooking methods are taken into consideration in the ITJ database.

In summary, although few significant differences were found, the values calculated from the ITJ were closer to the analytical values in most cases than those calculated from the STJ, and the correlations between analytical values and values calculated from the ITJ were slightly stronger than those calculated from the STJ, except for carbohydrates. From these findings, values calculated from the ITJ are more accurate than those calculated from the STJ. To obtain more accurate data in nutritional surveys, food composition tables like the ITJ, in which changes in nutrient composition due to cooking methods are taken into consideration, should be used. While supplements taken by ordinary people to obtain certain nutrients were not included in the hospital meals used as samples in this study, the ITJ makes it possible to evaluate nutrient intake from supplements, whereas the STJ is not geared to handle this. Therefore, the ITJ can be a useful tool in future nutritional surveys in Japan and in international comparative studies.

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